2016

# ELECTRICAL TECHNICAL DOCUMENTS.
## ( ELECTRICAL CALCULATIONS )

THE BASIC CONCEPT BEHIND THIS BOOKLET IS TO PROVIDE THE SIMPLEST WAY TO FIND OUT THE ELECTRICAL CALCULATION.

THE BOOK IS GENERAL INFORMATION ABOUT THE BASIC OF THE ELECTRICAL CALCULATIONS WHICH IS RARELY FOUND IN THE COLLECTED MANNER. WE VERY WELL KNOWN THAT THE ELECTRICAL ENGINEER VERY WELL KNOWN WITH ELECTRICAL CONCEPT OF LT,HT & POWER SYSTEM BUT WITH RESPECT TO THIS THE MOST OF THE ENGINEERS DON'T WANT TO KNOW THE BASIC BEHIND THE ALL THESE CONCEPT.

OUR AIM VERY CLEAR & TRANSPARENT WHICH IS TO PROVID ,THE VERY EASY SOLUTION FOR THE ENGINEERS THOSE ARE INTERESTED TO KNOW THE BASICS & SHADOWS OF THE ELECTRICAL CALCULATION.

I AM PROUD TO BE AN ELECTRICAL ENGINEER & I WILL DO SOMETHING FOR MY WORLD WHICH WILL MAKE ME REMEMBER IN HISTORY.

PART - 1

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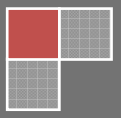

# ENGINEERING DETAILS

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# ENGINEERING DETAILS

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# ENGINEERING DETAILS

*II JAI GANESH II*

# ENGINEERING DETAILS

## DEFINATIONS

1. IN 3 PHASE STAR SYSTEM = PHASE VOL. = $\sqrt{3}$ ***LINE VOL.***

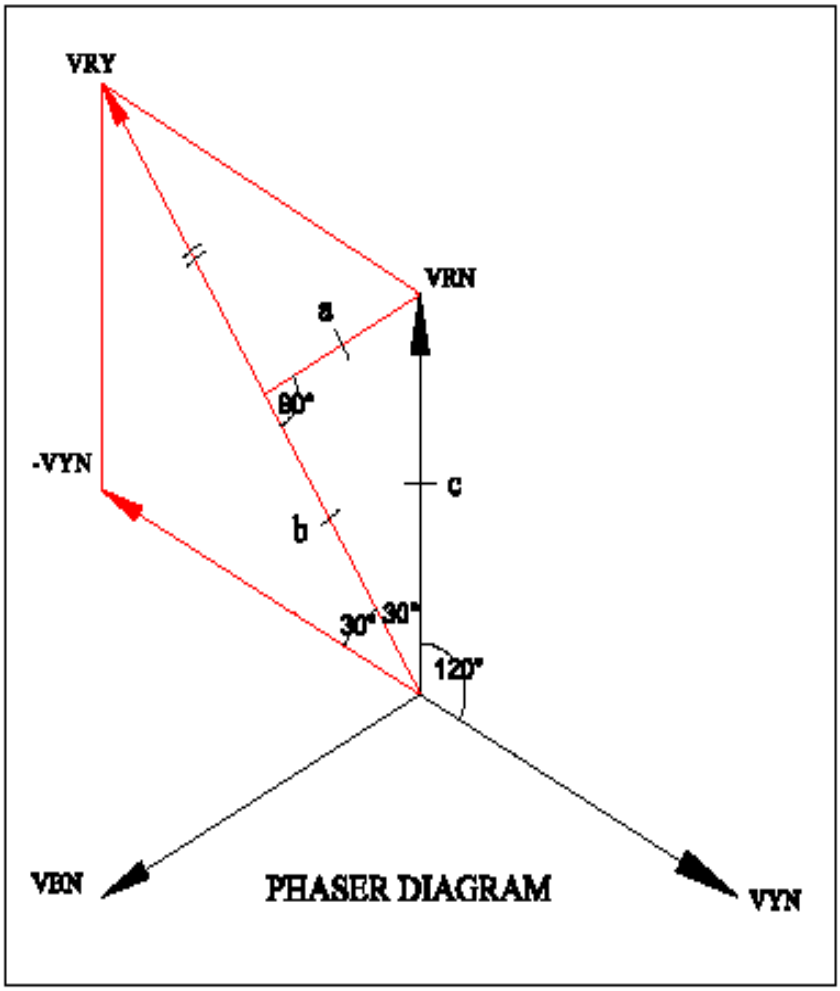
   = LINE CURRENT = PHAE CURRENT.

   IN 3 PHASE DELTA SYSTEM =LINE VOL. = ***PHASE VOL.***.

   = PHASE CURRENT = $\sqrt{3}$ LINE CURRENT.

THEN HOW TO CAME $\sqrt{3}$ IN ABOVE FORMULA.

ANS : -




∴ VRY = VRN + ( - VYN )

***NOTE*** : VRY IS THE RESULTANT OF VRN & ( -VYN )

$$\therefore \ COS\ 30 = {}^{b}/_{c}$$

$$\therefore COS\ 30 = {}^{\frac{VRY}{2}}/_{VRN}$$

NOW, PUT THE VALUE IN ABOVE FORMULA,

$$\therefore \frac{VRY}{2} = VRN\ COS\ 30$$

$$\therefore \frac{VRY}{2} = VRN\ \frac{\sqrt{3}}{2}$$

$$\therefore \ VRY = \sqrt{3} VRN$$

MEANS, LINE VOL = $\sqrt{3}$***X PHASE VOL***. ( AS PER ABOVE FORMULA )

EXAMPLE:

LINE VOL. ( VRY ) :- 433 VOLTS

FIND PHASE VOL. ( VRN ) = ?

PUT THE VALUE IN ABOVE FORMULA :

$$\therefore \ 433 = \sqrt{3} VRN$$

$$\therefore \frac{433}{\sqrt{3}} = VRN$$

∴ VRN ( PHASE VOL )= 250 VOLTS.

# ENGINEERING DETAILS

*NOTE :-WE ALSO CALCULATE LINE VOL. WHEN WE KNOW PHASE VOL. USING ABOVE FORMULA.*

2. VOL.SAG :- BELOW 90% OF RATED VOL.

**VOL. SWELL :- OVER 110% OF RATED VOL.**

3. NOMINAL SYSTEM VOLTAGE : - NOMINAL SYSTEM VOLTAGE IS THE PHASE TO PHASE VOLTAGE OF THE SYSTEM FOR WHICH THE SYSTEM IS NORMALLY DESIGNED. SUCH AS 11KV,22KV,33KV,132KV,220KV,400KV.
4. HIGHEST SYSTEM VOLTAGE: - HSV MEANS MAXIMUM ALLOWABLE VOLTAGE. IT IS ALSO MEASURED IN PHASE TO PHASE MANNER.

| NOMINAL SYSTEM VOLTAGE | 11KV | 22KV | 33KV | 132KV | 220KV | 400KV |
|---|---|---|---|---|---|---|
| **HIGHEST SYTEM VOLTAGE** | **12KV** | **24KV** | **36KV** | **145KV** | **245KV** | **420KV** |

NORMALLY HIGHEST SYSTEM VOLTAGE IS 110%OF CORRESPONDING NOMINAL SYSTEM VOLTAGE UPTO VOLTAGE LEVEL OF 220KV,& FOR 400KV & ABOVE IT IS 105%.

5. OVER VOLTAGE :- OVER VOLTAGE UPTO 110% OF RATED.
6. UNDER VOLTAGE :- UNDER VOLTAGE UPTO 90% OF RATED.
7. INTERRUPTION OF VOL. :- BELOW 10% OF SYSTEM VOL.
8. INSTANTANEOUS VALUE : - AT ANY INSTANTS VALUE.

9. DC OFF SET :- PRESENCE OF DC IN AC WAVE FORM.

10. ACTIVE POWER ALWAYS SHOW IN COS VALUE.

11. REACTIVE POWER ALWAYS SHOW IN SIN VALUE.

**12.** AC VALUES " DIRECTION & MAGNITUDE CONTINUOUSLY CHANGE WITH RESPECT OF TIME ".

13. AC VOLTAGE :- ALTERNATING QUANTITY OF VOLTAGE.

( IN AMERICAN ACCENT " Q '' REPRESENTS " C '' )

14. AC CURRENT :- ALTERNATING QUANTITY OF CURRENT.

( IN AMERICAN ACCENT " Q '' REPRESENTS " C '' )

15. INRUSH CURRENT :- INRUSH CURRENT IS THE CURRENT THAT A LOAD DRAWS WHEN THE SUPPLY IS SWITCHED ON.

16. LMLA BATTERY = LOW MAINTANANCE LEAD ACID BATTERY TYPE.

17. VRLA BATTERY = VALVE REGULATED LEAD ACID BATTERY TYPE.

18. HDP = HIGH DISCHARGE PERFORMANCE BATTERY TYPE.

19. EXTRA LOW VOLTAGE ( ELV ) = NOT EXCEEDING 50VOLTS.

20. LOW VOLTAGE ( LV ) = NORMALLY EXCEEDING 50VOLTS & NOT MORE THAN 250 VOLTS.

21. MEDIUME VOLTAGE ( MV ) = NORMALLY EXCEEDING 250 VOLTS BUT NOT EXCEEDING 650 VOLTS.

# ENGINEERING DETAILS

22. HIGH VOLTAGE ( HV ) = NORMALLY EXCEEDING 650 VOLTS BUT NOT EXCEEDING 33 KV.

23. EXTRA HIGH VOLTAGE ( EHV ) = NORMALLY EXCEEDING 33 KV.

24. FLASHOVER VOLTAGE : - DISCHARGE AROUND OR OVER THE SURFACE OF AN INSULATORS.

25. SPARKOVER VOLTAGE :- DISCHARGE BETWEEN ELECTRODE & PROTECTIVE EQUIPMENT.

26. WITHSTAND VOLTAGE : - HIGHEST VALUE OF APPLIED VOLTAGE AT WHICH EQUIPMENT WILL NOT FLASHOVER.

27. DIELECTRIC WITHSTAND TEST : - ALSO CALLED " HIGH POTENTIAL " OR " HIPOT "TEST. THIS TEST PERFORMED ON A COMPONENT OR PRODUCT TO DETERMINE THE EFFECTIVENESS OF ITS INSULATION.

28. WHAT IS MEAN BY BAY?

ANS = BAY REFERS TO THE AREA OCCUPID BY ONE CKT. BREAKER & ASSOCIATED EQUIPMENTS ( ISOLATORS,CT,PT ) USED TO PROTECT ONE FEEDER/LINE/BUS COUPLER IN BUS SYSTEM.

29. ZERO DATE = ZERO DATE OF THE CONTRACT SHALL MEAN THE DATE ON WHICH THE SITE IS HANDED OVER TO THE CONTRACTOR.

30. WHY WE USE OF ISOLATORS IN SUBSTATIONS OR DEFINATION OF ISOLATORS?

ANS :- WHEN CIRCUIT BREAKER TRIPS WE CANNOT BE VISIBLE INSIDE BREAKER CONTACTS & THAT IS WHY IT IS NOT RECOMMENDED NOT TO TOUCH ANY ELECTRICAL CIRCUIT JUST BY SWITCHING OFF THE CIRCUIT BREAKER.SO FOR BETTER SAFETY THERE MUST BE SOME ARRANGEMENT SO THAT ONE CAN SEE OPEN CONDITION OF THE SECTION OF THE CIRCUIT BEFORE TOUCHING IT.ISOLATOR IS A MECHANICAL SWITCH WHICH ISOLATES A SECTION FROM SYSTEM AS & WHEN REQUIRED.

# ENGINEERING DETAILS

NOTE :- ISOLATORS MUST BE OPEN AFTER CIRCUIT BREAKER OPEN & CLOSE BEFORE CIRCUIT BREAKER CLOSE.

31. KINDS OF TESTS.( DIFFERENCE BETWEEN TEST )

a. ROUTINE TEST :- A TEST TO WHICH EACH INDIVIDUAL EQUIPMENT IS SUBJECTED.( IT MEANS TEST EVERY EQUIPMENT IN ROUTINE TEST )

b. TYPE TEST :- A TEST MADE ON A EQUIPMENT WHICH IS REPRESENTATIVE OF OTHER EQUIPMENTS,TO DEMONSTRATE THAT THESE EQUIPMENTS COMPLY WITH SPECIFIED REQUIREMENTS NOT COVERED BY ROUTINE TEST.

c. SPECIAL TEST :- A TEST OTHER THAN A TYPE TEST OR ROUTINE TEST,AGREED BY THE MANUFACTURER & PURCHASER.

d. PRE-COMMISSIONING TEST : - THESE TEST ARE CONDUCTED AT SITE ON EACH EQUIPMENT AT SITE AFTER INSTALLATION & BEFORE FINAL COMMISSIONING.

32. MCB : - MINIATURE CIRCUIT BREAKER.

a. SP MCB : - IN SINGLE PHASE SUPPLY TO BREAK THE PHASE ONLY.

b. DP MCB : - IN SINGLE PHASE SUPPLY BREAK PHASE & NEUTRAL.

c. TP MCB : - IN THREE POLE MCB SWITCHING & PROTECTION IS AFFECTED IN ONLY 3 PHASES & THE NEUTRAL IS NOT PART OF THE MCB.

d. TPN ( 3P + N ) MCB : - IN TPN MCB, NEUTRAL IS THE PART OF THE MCB, BUT NEUTRAL POLE WITHOUT GIVEN ANY PROTECTION. NEUTRAL IS JUST AN ISOLATING POLE.

e. 4 POLE MCB : - IN 4 POLE MCB 3 PHASE & NEUTRAL HAS GIVEN SAME PROTECTION.WE CAN USE ANY OF POLE FOR PHASE & NEUTRAL

f. LET THROUGH ENERGY ( ENERGY LIMIT CLASS ) ( MCB/MCCB/FUSE ) : - LET THROUGH ENERGY IS THE AMOUNT OF ENERGY THAT WILL BE LET THROUGH IN A SHORT CIRCUIT CONDITION.

g. IΔn : - SENSIVITY OF EARTH LEAKAGE CURRENT.( JUST LIKE 30mA,100mA,300mA ) ( THIS IS SPECIALLY MENTION ON ELCB/RCCB/RCBO )

h. $I_m$: - MAKING & BREAKING CAPCITY OF RCCB Im IS THE MAXIMUM CURRENT THE RCCB IS ABLE TO BREAK SUCCESSFULLY.( THIS IS SPECIALLY MENTION ON ELCB/RCCB/RCBO )

NOTE : - IT SHOULD BE NOTED THAT SUCH RCCB/RCBO CAN ONLY BE USEDTO SUPPLIMENT AN EARTH CONDUCTOR & NOT REPLACE ONE.

HIGH SPEED CURRENT LIMITING ACTION ENSURES THAT THE MCB OPERATES BEFORE THE FULL FAULT CURRENT IS ALLOWED TO DEVELOP.THE TOTAL ENERGY LET THROUGH DEPENDS ON THE VALUE OF CURRENT& THE TIME FOR WHICH IT FLOWS,& DENOTED BY THE SYMBOL $I^2t$. THE HIGH SPEED CURRENT LIMITING ACTION ENSURES THAT THE ENERGY LET THROUGH & ANY SUBSEQUENT DAMAGE IS MINIMIZED.

LET THROUGH ENERGY IS USEFUL IN SIZING DOWNSTREAM CABLES.THE NUMBER SHOWN IS THE ENERGY LIMITING CLASS OF THE DEVICE.

NORMALLY WE USE CLASS 3& THIS IS HIGH SPEED ENERGY LIMIT CLASS.

i. ALL MCB/MCCB/ACB ARE NO LOAD LINE BIAS MEANS EITHER SIDE OF MCB/MCCB/ACB TERMINAL CAN BE USED AS LOAD OR LINE.

33.DIFFERENCE BETWEEN ELCB & RCCB ?

ANS : - ELCB IS A VOLTAGE OPERATED CIRCUIT BREAKER & RCCB IS A CURRENT OPERATED CIRCUIT BREAKER.IN ELCB CONNECT PHASE,NEUTRAL & EARTH WIRE. AN ELCB REQUIRED SOUND EARTH CONNECTION. ELCB CONTINUOUSLY MONITOR THE VOLTAGE BETWEEN

METALIC BODY & GROUND WIRE. IF THE VOLTAGE RISE MORE THAN 50VOLT DUE TO LIVE WIRE TOUCH TO METAL BODY OR INSULATION FAILURE OF THE EQUIPMENT ELCB RELAY COIL SENSE THIS VOLTAGE & TRIP THE ELCB.

RCCB DOES NOT REQUIRED EARTH CONNECTION , IT ONLY REQUIRED PHASE & NEUTRAL ONLY & NO NEED OF EARTH WIRE.RCCB IS MORE SENSITIVE THAN ELECB'S.

34. $I^2R$ LOSS = COPPER LOSS.

HOW TO CAME $I^2R$?

P = V X I

& V = I X R ( AS PER OHMS LAW )

SO, WE WRITE $I^2R$.

EXAMPLE OF $I^2R$ LOSS :-

SYSTEM VOL. – 110KV

CONDUCTOR USED - .4ACSR ZEBRA CONDUCTOR.

LOAD CURRENT – 100AMP.

CONDUCTOR RESISTANCE - 10 Ω/KM.

FORMULA :- $I^2R$,

SO,

100 X 100 X 10 = 100,000 WATT

IN 110 KV SYSTEM $I^2R$ LOSS IS 100,000 WATTS.

IF WE INCREASED LINE VOL UP TO 220KV THEN FOLLOWING IS THE RESULT.

LOAD CURRENT – 50AMP ( DUE TO VOL. RISE. )

CONDUCTOR RESISTANCE IS SAME – 10 Ω/KM.

SO,

50 X 50 10 = 25000 WATTS

IN 220KV SYSTEM $I^2R$ LOSS IS 25000 WATTS.

CONCLUSION :- IF WE REDUCED LOAD CURRENT ( BY INCREASING SYSTEM VOL.) HAPPENED LESS TRANSMISSION LOSSES.

## 35. NO 0F LIGHT FIXTURES REQUIRED FORMULA.( FOR COMMERCIAL & INDUSTRIAL USE ONLY )

1 LUX – 1 LUMENS PER SQ. MTR. IS CALLED 1 LUX.

( RISING SUN GIVES 500 LUX, MID-DAY SUMMER GIVES 100 000 LUX, & FULL MOON GIVES ONLY 0.25LUX.)

NO OF FIXTURES = AREA X REQUIRED LUX / Cuf X MF X LUMENS O/P.

Cuf : - COMMON UTILIZATION FACTOR.( DEPENDS ON ROOM INDEX VALUE )

MF : - MAINTANANCE FACTOR.( ALWAYS CONSIDER 0.7 )

LUMENS OUTPUT : - LUMENS OUTPUT VALUE MENTIONED ON LAMP.

ROOM INDEX ( RI ) = ROOM LENGTH X WIDTH / ( L + W ) X HEIGHT FLOOR LEVEL.

IF CALCULATED RI VALUE IS < 0.5( LESS THAN ),THEN CONSIDER MINIMUM Cuf = 0.5

IF CALCULATED RI VALUE IS > 0.5( MORE THAN ), THEN TAKE Cuf. AS IT IS CALCULATED.

EXAMPLE : -

# ENGINEERING DETAILS

ROOM LENGTH X WIDTH X HEIGHT – 90Mtr. X 40Mtr. X 10Mtr.

250W MH LAMP LUMENS O/P – 15000

REQUIRED LUX LEVEL – 400 LUX.

SO,

1st STEP – CALCULATE ROOM INDEX ( RI )

RI = L X W / ( L + W ) X HFL

RI = 90 X 40 / ( 90 + 40 ) X 10

RI = 2.7

2nd STEP –

NO OF FIXTURES REQD. = AREA X REQUIRED LUX / Cuf X MF X LUMENS O/P.

PUT THE VALUES IN ABOVE FORMULA.

3600 X 400 / 2.7 X 0.7 X 15000

NO OF FIXTURES REQUIRED = 51 NOS.

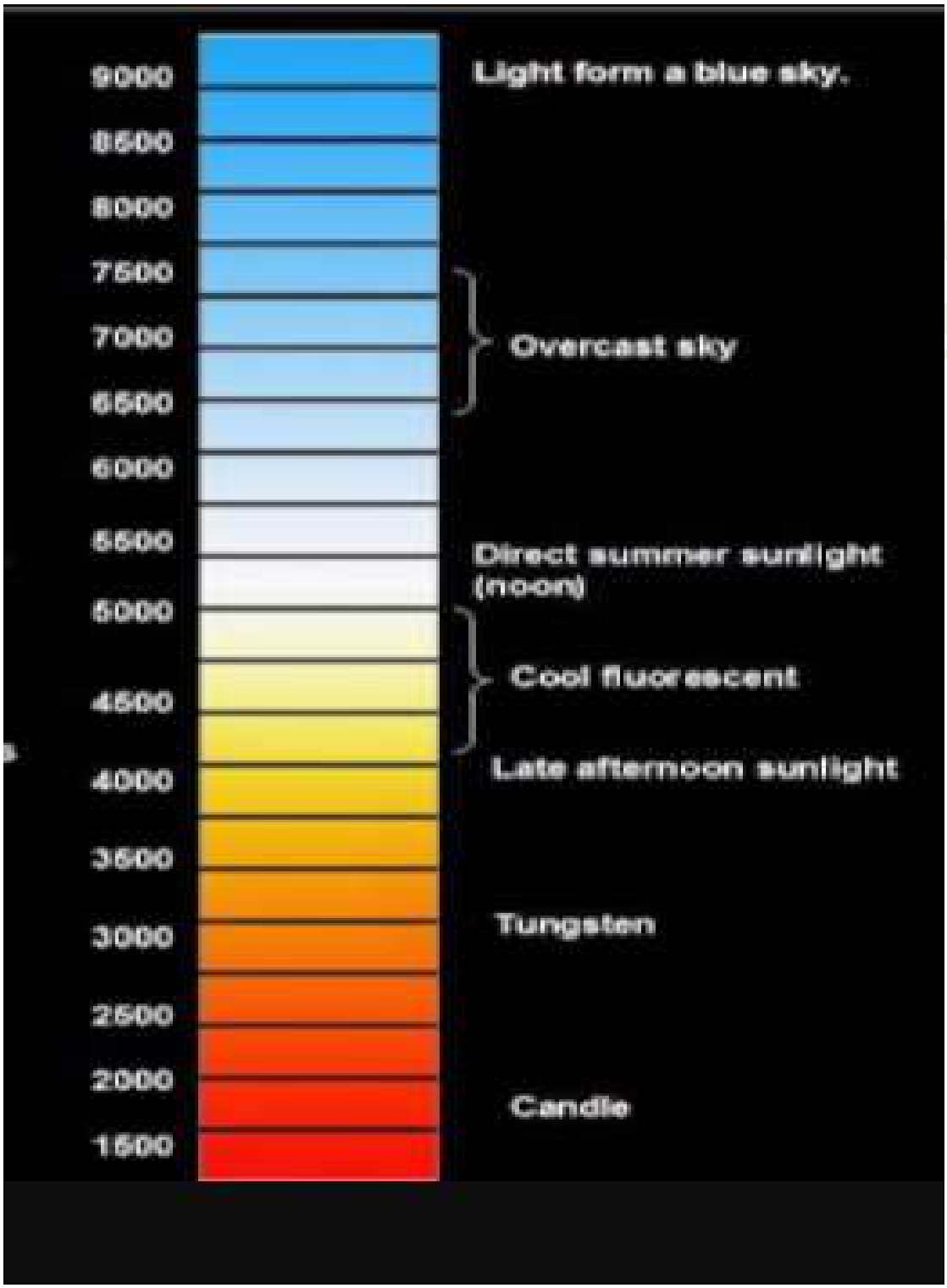
36. KELVIN :- KELVIN IS ALWAYS USED IN THE MEASURE OF THE COLOUR TEMPERATURE OF LIGHT SOURCE. COLOUR TEMPERATURE IS A MEASURED OF LIGHT ENERGY EXPRESSED IN DEGREES IN KELVIN NOT HEAT FARENHEIT OR CELSIUS.HIGHER COLOUR TEMP.MEAN THAT THE LIGHT SOURCE IS CLOSER TO THE BLUE END OF THE FOLLOWING SPECTRUM,& LOWER COLOUR TEMP.MEAN THE LIGHT SOURCE IS CLOSER TO THE RED END OF THE FOLLOWING SPECTRUM. BLACK BODIES WITH TEMPERATURE BELOW ABOUT 4000K APPEAR REDDISH WHEREAS THOSE ABOVE ABOUT 7500K APPEAR BLUISH. COLOUR TEMPERATURE IS IMPORTANT IN INDUSTRY OR PHOTOGRAPHY, WHERE A COLOUR TEMPERATURE OF APPROXIMATELY 5600K IS REQUIRED TO MATCH " DAYLIGHT ".SEE SPECTRUM FIGURE.

THE COLOUR TEMPERATURE OF SUNLIGHT ABOVE THE ATMOSPHERE IS ABOUT 5,900 K.

# ENGINEERING DETAILS

CRI : ( COLOUR RENDERING INDEX ) : -

CCT :- ( CORRELATED COLOUR TEMPERATURE ) : -



# ENGINEERING DETAILS

## ( SPECTROM )

### KIOSK CALCULATIONS

IT IS USED FOR HT CONSUMER METERING ( MOSTLY INDUSTRIAL & COMMERCIAL), BELOW 1MVA LOAD USE ONE KIOSK ONLY&AFTER 1MVA LOAD USE TWO KIOSK ONE FOR CONSUMER METERING & SECOND FOR CHECK METERING.IT MEANS 2 KIOSK CONNECT IN SERIES, IT's PURPOSE ONLY TO COMPARE CONSUMER KIOSK METER & CHECK METER READINGS ARE SAME OR NOT.IN KIOSK COMPRISES 3 NOS OF CT & 3 NOS OF PT SHALL BE MOUNTED.THE CTs & PTs SHALL BE OF CAST RESIN TYPE ( INSULATION CLASS E $120^0$ ) & SHALL BE ABLE TO WITHSTAND THERMAL & MECHANICAL STRESSES DURING SHORT CKT. & MOMENARY CURRENT RATINGS.

HOW TO CALCULATE KIOSK MULTIFACTOR ( MF )

$$\frac{KIOSK\ CT\ RATIO}{METER\ CT\ \ RATIO} \mathbf{X} \frac{KIOSK\ PT\ RATIO}{METER\ PT\ RATIO} \mathbf{X}\ SMF$$

SMF = ALWAYS CONSIDER 1. ( WHEN WE USED DISC TYPES METER WE TAKE SMF ON METERS WHICH SCALE WE USE. NOW WE USE DIGITAL METERS & HE SHOWS DIRECT READINGS,SO WE CONSIDER 1 )

### KIOSK MULTIFACTOR CALCULATION

KIOSK CT RATIO – 10/5A

KIOSK OT RATIO – 22KV / 110V

METER CT RATIO – 5/5A ( MENTIONED ON MSEDCL METER )

METER PT RATIO – 11KV / 110V ( MENTIONED ON MSEDCL METER )

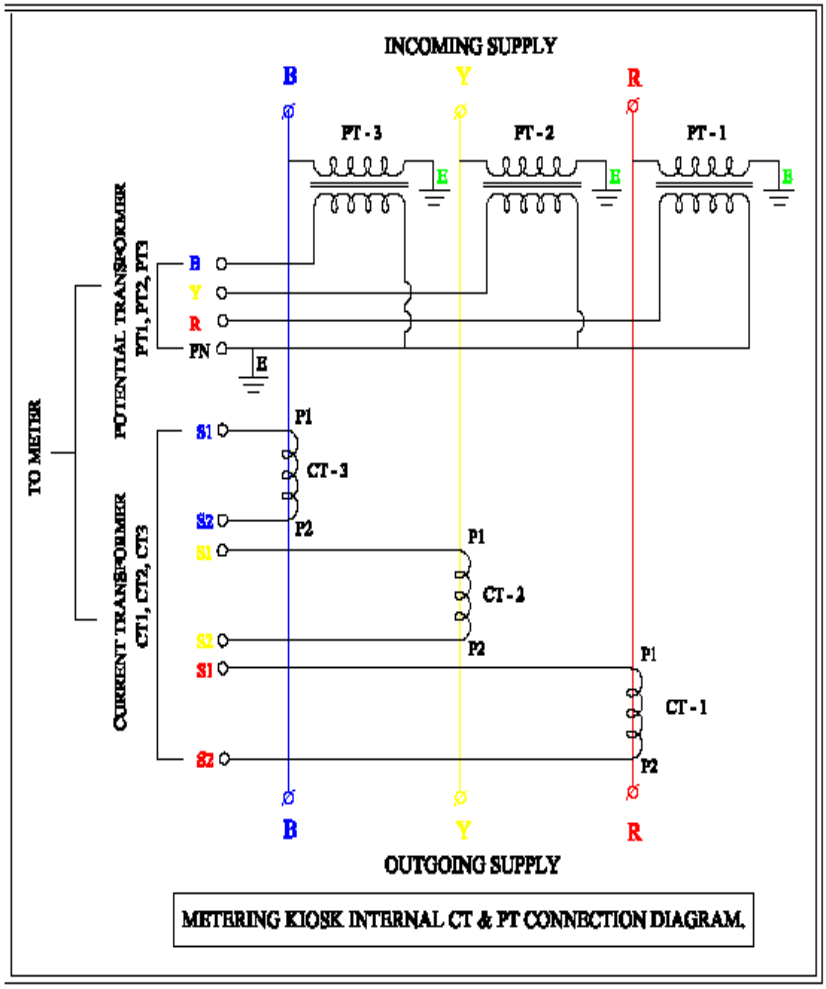
NOW,PUT THE VALUE IN ABOVE FORMULA

# ENGINEERING DETAILS

$$\frac{\frac{10}{5}}{\frac{5}{5}} \times \frac{\frac{22000}{110}}{\frac{11000}{5}} \times SMF$$

∴10 /5 X 5 / 5 X 22000 / 110 X 110 / 11000

KIOSK MULTIFACTOR IS = 4



# ENGINEERING DETAILS

KIOSK EARTHING QTY :-

a. CT BODY – 2 NOS.
b. CT SEC : - 1 NOS.
c. PT BODY : - 2 NOS.
d. PT SEC : - 1 NOS.

THESE 6 MAIN EARTH POINTS ARE PRESENT AT KIOSK CUBICLE BACKSIDE.

e. METERING CUBICLE BODY : - 2 NOS.
f. I/C & O/G HT CABLE BRAIDED LINK :- 2 NOS.

NOTE : - THERE IS A COMPULSION TO DO KIOSK EARTHING IN COPPER ONLY.

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# ENGINEERING DETAILS

## ❖ TRANSFORMER

NOTE : - TRANSFORMER IS A STATIC DEVICE.( WHICH DOES NOT CONTAIN ANY ROTATING OR MOVING PARTS )WHICH IS USED TO TRANSFER ELECTRICAL ENERGY FROM ONE AC CKT. TO ANOTHER CKT.WITH INCREASE / DECREASE IN VOLTAGE / CURRENT BUT WITHOUT ANY CHANGE IN FREQUENCY.

WHEN TRANSFORMER IS FULL LOAD 100%, THAT TIME IRON LOSS IS EQUAL TO COPPER LOSS.& THAT TIME TRANSFORMER %EFFICIENCY ( %n ) IS MORE .

WHY HV WINDING IS ON LV WINDING OR LV WINDING WOUND NEAR THE CORE ?

ANS : - IF THE HIGH VOLTAGE WINDING IS WOUND NEXT TO THE CORE & HEAVY INSULATION WILL HAVE TO BE PROVIDE TO AVOID THE EARTH LEAKAGE & THE COST OF CONSTRUCTION WILL INCREASE.

SO THAT THE LOW VOLTAGE WINDING IS PLACED NEXT TO THE CORE & THE HIGH VOLTAGE WINDING IS PLACED OUTSIDE THE LOW VOLTAGE WINDING.THE CORE LOW VOLTAGE WINDING AS WELL AS HIGH & LOW VOLTAGE WINDINGS ARE INSULATED WITH BACKELITE FORMERS.

HOW TO CALCULATE TRANSFORMER SIZE IN KVA ?

FORMULA –

$$KVA = \sqrt{3} X\ LINE\ VOL(VL) X\ LINE\ CURRENT(IL) X \cos\emptyset$$

EXAMPLE :-

CALCULATE 1 MVA TRAFO. ( OIL COOLED ) RATED PRIMARY & SEC.CURRENT.

PRIMARY VOL. – 22KV

SECONDARY VOL. - .433KV

% Z –4.72 % ( FOR NORMAL TAP )

# ENGINEERING DETAILS

VECTOR GROUP – Dyn11

COSØ – CONSIDER 1( UNITY )

FIRST CALCULATE TRAFO. PRI. CURRENT

SO,

1000000 = 1.732 X 22000 X IL X 1

∴ 1000000 / 38104

PRI. RATED CURRENT = 26.24 AMP.( THIS IS TRAFO. RATED NAMEPLATE CURRENT )

NOW CALCULATE SEC. CURRENT

SO,

1000000 = 1.732 X 433 X 1

∴ 1000000 / 749.96

RATED SEC. CURRENT = 1333.40AMP.( THIS IS TRAFO.RATED NAMEPLATE CURRENT )

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EXAMPLE :

TRAFO. RATING – 1MVA. ( OIL COOLED )

% Z – 4.72% ( FOR NORMAL TAP )

PRI. VOLRAGE – 22KV.

SEC. VOLTAGE – 433VOLT.

VECTOR GROUP – Dyn11

FREQUENCY – 50Hz

SO,

HOW TO CALCULATE TRANSFORMERS FAULT CURRENT.

# ENGINEERING DETAILS

THERE ARE TWO METHODS OF CALCULATE FAULT CURRENT. THESE ARE FOLLOWS.

1. MVA BASE METHOD.
2. CURRENT BASE METHOD.

FIRST WE USE MVA BASE METHOD FOR ABOVE TRAFO. PARAMETERS.

FORMULA - ***TRAFO MVA CAPACITY*** /% ***Z***

GET ANS. IN MVA.

= MVA / $\sqrt{3}$***X SYSTEM VOL***

FIRST WE CALCULATE TRAFO. PRI. SIDE FAULT CURRENT…

= 1 / .0472

= 21.186MVA( 21.186 X 1000000 = 21186000 / 1000 ( FROM 22000 ) =21186 )

= 21186 / 1.732 X 22

TRAFO PRI. SIDE FAULT CURRENT= 556.00AMP. (0.556kA)

NOW WE CALCULATE TRAFO. SEC. SIDE FAULT CURRENT…

= 1 / .0472

= 21.186MVA

= 21186 / 1.732 X .433

TRAFO SEC. SIDE FAULT CURRENT= 28249.50AMP. ( 28.25 kA)

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NOW WE CALCULATE TRAFO FAULT CURRENT USING CURRENT BASE FORMULA.

FORMULA – FOR PRI. FAULT CURRENT.

***RATED PRI. CURRENT*** /%***Z***

FORMULA – FOR SEC. FAULT CURRENT.

# ENGINEERING DETAILS

***RATED SEC. CURRENT /%Z***

PRI. FAULT CURRENT = 26.24 / .0472

PRI. FAULT CURRENT = 556.00 AMP ( .556kA )

SEC. FAULT CURRENT = 1333.40 / .0472

SEC. FAULT CURRENT = 28250.00 AMP ( 28.25Ka )

CONCLUSION:- FAULT CURRENT VALUE MATCHES BOTH MVA BASE & CURRENT BASE METHODS.WE USE ANYONE OF ABOVE.

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WHAT IS TRANSFORMER PERCENTAGE IMPEDANCE ( % Z )

THE %Z OF A TRANSFORMER IS THE VOLTAGE DROP ON FULL LOAD& FULL RATED CURRENT DUE TO THE WINDING LEAKAGE REACTANCE EXPRESSED AS PERCENTAGE OF THE RATED VOLTAGE.

THE IMPEDANCE OF A TRANSFORMER HAS A MAJOR EFFECT ON SYSTEM FAULT LEVEL. A TRANSFORMER WITH A LOWER IMPEDANCE VALUE WILL LEAD TO HIGHER FAULT LEVEL & TRANSFORMER WITH HIGHER IMPEDANCE VALUE WILL LEAD TO LOWER FAULT LEVEL.

WHAT IS LEAKAGE REACTANCE ?

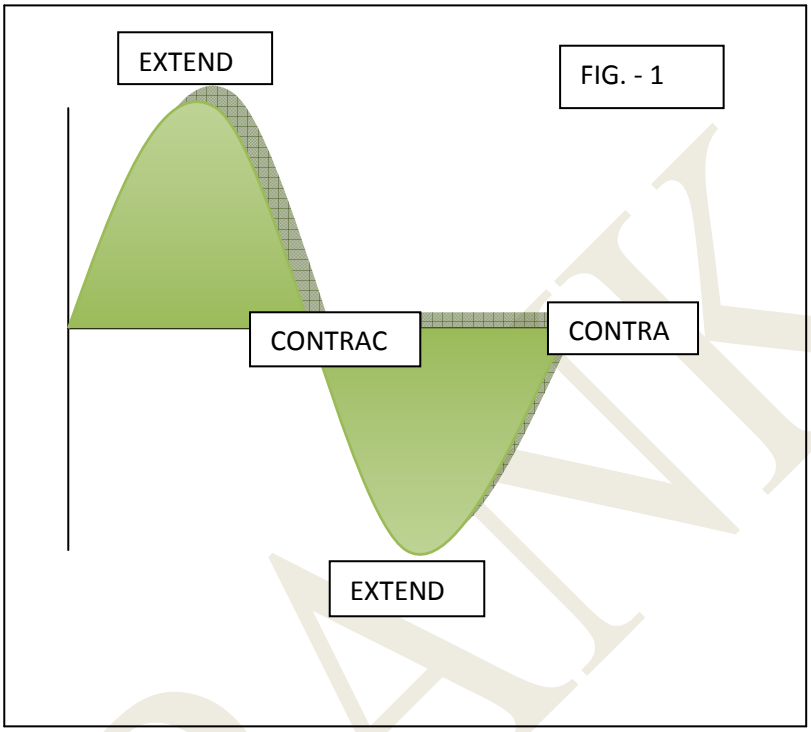
ANS : - IT IS ASSUMED THAT THE ENTIRE FLUX PRODUCED BY THE PRIMARY, LINKS WITH THE SECONDARY WINDINGS. BUT IN PRACTICE IT IS NOT POSSIBLE. PART OF THE PRIMARY FLUX AS WELL AS SECONDARY FLUX COMPLETES THE PATH THROUGH AIR & LINKS WITH THE RESPECTIVE WINDING ONLY.SUCH FLUX IS CALLED LEAKAGE FLUX.

LEAKAGE FLUXES LINK WITH THE RESPECTIVE WINDINGS ONLY & NOT TO BOTH THE WINDINGS. " TO REDUCE LEAKAGE REACTANCE BOTH THE WINDINGS ARE PLACED ON SAME LIMB RATHER THAN ON SEPARATE LIMB.

TRANSFORMER HUMMING THEORY.

# ENGINEERING DETAILS

TRANSFORMET NOISE IS CAUSED BY A PHENOMENON CALLED MAGNETOSTRICTION. IN VERY SIMPLE TERMS THIS MEANS THAT IF A PIECE OF MAGNETIC SHEET STEEL IS MAGNETISED IT WILL EXTEND ITSELF. WHEN THE MAGNETISATION IS TAKEN AWAY , IT GOES BACK TO ITS ORIGINAL SHAPE. A TRANSFORMER IS MAGNETICALLY EXCITED BY AN ALTERNATING VOLTAGE & CURRENT,SO THAT IT BECOMES EXTEND AND CONTRACTED TWICE DURING A FULL CYCLE OF MAGNETISATION.( SEE FIG. 1 )




THIS EXTRACTION & CONTRACTION IS NOT UNIFORM, CONSEQUENTLY THE EXTENSION & CONTRACTION VARIES ALL OVER A SHEET.

A TRANSFORMER CORE IS MADE FROM MANY SHEETS OF SPECIAL STEEL. IT IS MADE THIS WAY TO REDUCE LOSSES & TO REDUCE THE CONSEQUENT HEATING EFFECT.THESE EXTENSIONS ARE ONLY SMALL DIAMENSIONALLY & THEREFORE CANNOT USUALLY BE SEEN BY THE NAKED EYES. THEY ARE HOWEVER, SUFFICIENTLY TO CAUSE A VIBRATION & AS A RESULT NOISE.

WHAT IS MEAN BY TRANSFORMER VECTOR GROUP ?

# ENGINEERING DETAILS

THE VECTOR GROUP PROVIDES A SIMPLE WAY OF INDICATING HOW THE INTERNAL CONNECTIONS OF A PARTICULAR TRANSFORMER ARE ARRANGED. THIS SYSTEM ADOPTED BY IEC.THE VECTOR GROUP IS INDICATED BY A CODE CONSISTING OF TWO OR THREE LETTERS.

IEC – INTERNATIONAL ELECTROTECHNICL COMMISSIONING.

THE VECTOR GROUP LETTERS INDICATE THE WINDING CONFIGURATION AS FOLLOWS.

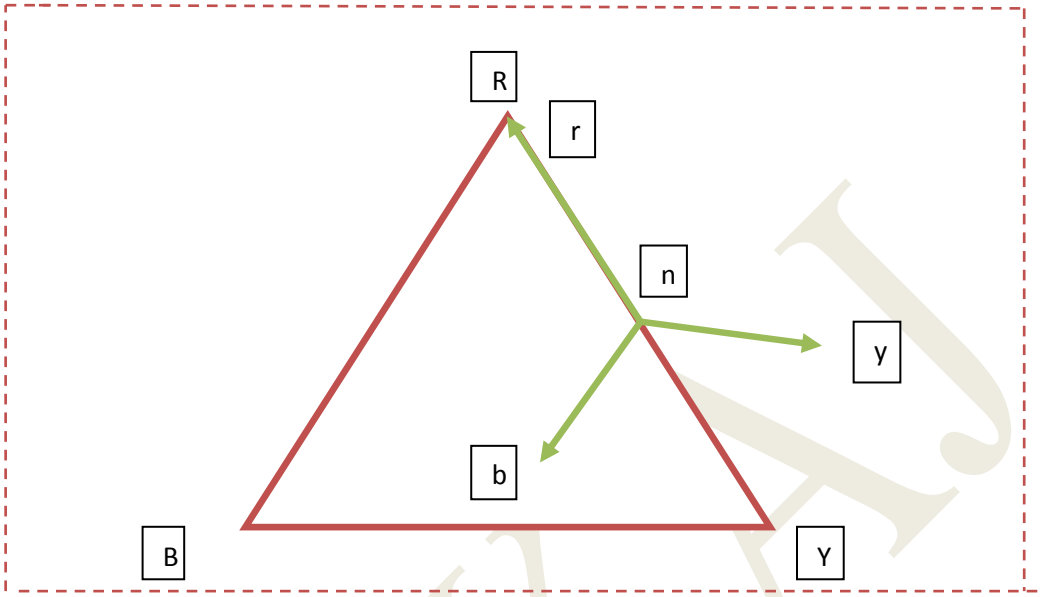
1. D : DELTA WINDING,ALSO CALLED A MESH WINDING.
2. Y : Wye WINDING, ALSO CALLED A STAR WINDING.
3. Z : Zigzag WINDING, ALSO CALLED INTERCONNECTED STAR WINDING.THIS TRANSFORMER HAVE A SPECIAL CHARACTERISTICS & ARE NOT COMMONLY USED WHERE THESE CHARACTERISTICS ARE NOT NEEDED.
4. I : INDEPENDENT WINDING. IN THIS TYPE THREE WINDINGS ARE NOT CONNECTED INSIDE THE TRANSFORMER AT ALL & MUST BE CONNECTED EXTERNALLY.

IN THE IEC VECTOR GROUP CODE, EACH LETTER STANDS FOR ONE SET OF WINDINGS. THE PRIMARY WINDING IS DESIGNED WITH A CAPITAL LETTER, WHILE THE OTHER WINDINS ARE DESIGNATED WITH A lower CASE.

THE DIGITS FOLLOWING THE LETTER CODES INDICATE THE DIFFERENCE IN PHASE ANGLE BETWEEN THE WINDINGS, IN UNITS OF 30 DEGREE.

FOR EXAMPLE : Dyn11 PRIMARY DELTA WINDING SECONDARY STAR WINDING. THE PHASE ANGLE OF THE SECONDARY LAGS THE PRIMARY BY ( 11 x 30° = 330°DEGREE) = 330 DEGREE.

HOW TO CHECK ABOVE Dyn11 TRAFO VECTOR GROUP IS CORRECT OR NOT ?




R,Y,B = PRIMARI WINDING.

r,y,b,n = SECONDARY WINDING.

AS PER ABOVE Dyn11 VECTOR GROUP FOLLOWING STEPS ARE CARRIED OUT FOR TESTING Dyn11 VECTOR GROUP ARE CORRECT OR NOT.

STEPS: -

1. PRIMARY SIDE R Ø & SECONDARY SIDE r Ø EXTERNALLY SHORT.
2. APPLY 3 Ø,433VOLTS SUPPLY TO HV SIDE.

CHECK Rn + Yn = RY

∴ 4.90 + 426 = 431 VOL .

VBb < VBn < VBy

∴ 425 < 427 < 432 VOL .( < LESS THAN )

Yy = Yb

∴421 VOL. = 421 VOL.

# ENGINEERING DETAILS

EXAMPLE :

APPLIED VOLTAGE MEANS GIVEN TO HV SIDE OF TRAFO WDG.

| R Y | Y B | RB |
|---|---|---|
| 431 | 429 | 428 |

| | | | | |
|---|---|---|---|---|
| | R n | Y n | B b | |
| | 4.90 | 426 | 425 | |
| Y y | Y b | B n | B y | |
| 421 | 421 | 427 | 432 | |

WHAT IS MEAN BY OVEREXCITATION OF TRANSFORMER ?

' X ' MER OVEREXCITATION MEANS THAT THE MAGNETIC FLUX IN THE CORE IS INCREASED ABOVE THE NORMAL DESIGN LEVEL. OVEREXCITATION OF ' X 'MER IN TRANSMISSION & DISTRIBUTION NETWORKS IS CAUSED BY OVER VOLTAGE IN THE NETWORK.( THE OVER EXCITATION IS NOT AN INTERNAL ' X ' MER FAULT, ALTHOUGH CAN LEAD TO ONE.

IF OVEREXCITATION IS HAPPEN FOLLOWING ARE THE DRAWBACKS.

1. HEAT OF TRANSFORMER.
2. AGING OF TRANSFORMER IS AFFFECTED.
3. OVERHEATING OF NON-HEATING MATERIAL LIKE TRAFO. BODY.
4. INCREASE VIBRATION & NOISE OF TRANSFORMER.

IF THIS SITUATION ISN'T TAKEN CARE OF IT, TRANSFORMER CAN BE DAMAGE.

WHAT IS MEAN BY TRANSFORMER TURN TO TURN FAULT.?

TURN TURN FAULT BETWEEN A FEW TURNS & IS DIFFICULT TO DETECT BY CURRENT MEASURING RELAY. THE CURRENT IN THE SHORT CIRCUITED LOOP IS HIGH ( 50 – 100 TIME IN ) & CAUSES LOCAL DAMAGE & RELEASE OF GAS.

THEREFORE RATE OF RISE OF PRESSURE RELAY MAY DETECT THIS FAULT & OPERATE BUCHHOLZ ALARM & DIFFERENTIAL PROTECTION OPERATED.

NOTE –AFTER 5MVA & ABOVE TRANSFORMER FOLLOWING PROTECTION RELAY ARE COMPULSARY.

1. DIFFERENTIAL PROTECTION RELAY.
2. RESTRICTED EARTH FAULT RELAY.
3. OVERCURRENT RELAY.
4. OVERFLUXING RELAY.
5. OVERLOAD RELAY.
6. BUCHHOLZ RELAY.

## POLARIZATION INDEX VALUE OF TRANSFORMER

IT IS THE RATIO OF INSULATION RESISTANCE ( IR ) FOR 10MINUTES TO INSULATION RESISTANCE FOR 1 MINUTES. PI TEST MEASURES THE ABILITY OF THE INSULATION TO ABRORB VOLTAGE OVER A PERIOD OF TIME. THIS GIVES AN INDICATION OF THE OVERALL INSULATION QUALITY OF THE INDIVIDUAL PIECES OF INSULATION IN THE TRANSFORMER. THIS TEST IS USUALLY PERFORMED IN CONJUNCTION WITH THE MEGGER TEST.

IR 600 SEC VALUE / IR 60 SEC VALUE

THIS VALUE IF IT IS LESS THAN 1 THAT SYSTEM SHOULD BE REPLACE OR REPAIR. IF IT IS 1.3 OK & 1.5 IS GOOD & ABOVE IS VERY GOOD.

NOTE :- ITS MAXIMUM ACCEPTABLE VALUE DEPENDS ON THE CLASS OF INSULATION ALSO MINIMUM RECOMMENDED VALUE IR ( 60 SEC ) / IR ( 15 SEC ) SHOULD BE 1.3 FOR ALL CLASS OF INSULATION.

# ENGINEERING DETAILS

$$\textbf{POLARIZATION INDEX} = \frac{\textbf{INSULATION RESISTANCE AFTER 10 MINUTES.}}{\textbf{INSULATION RESISTANCE AFTER 1 MINUTES.}}$$

NOTE : - IT IS AN RATIO OF THE INSULATION RESISTANCE MEASURED FOR 10 MINUTES TO THE INSULATION RESISTANCE VALUE MEASURED AFTER 1 MINUTES,IT IS AN RATIO,SO IT DOES NOT HAVE ANY UNITS..

TRANSFORMER MAGNETIC BALANCE TEST : - IN THIS TEST WE HAVE CHECK FLUX CIRCULATION IS CORRECT OR NOT& TO IDENTIFY THE INTER TURN FAULTS.IN THIS TEST TWO PHASE SUPPLY 440 VOLTS APPLIED ACROSS TWO PHASES HV SIDE ONLY OF TRANSFORMER ,SAY 1U & 1V. THE W PHASE IS KEPT OPEN. THE VOLTAGE IS THEN MEASURED BETWEEN 1U1W & 1V1W THE SUM OF THESE TWO VOLTAGES SHOULD GIVE THE APPLIED VOLTAGES.

| OPEN PHASE | SUPPLIED PHASE | V R Y | V Y B | V B R | V r n | V y n | V b n |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| B-OPEN | R - Y | 100% | 2 / 3 | 1 / 3 | 100% | 2 / 3 | 1 / 3 |
| R-OPEN | Y - B | 50 % | 100% | 50 % | 50 % | 100 % | 50 % |
| Y-OPEN | R - B | 2 / 3 | 1 / 3 | 100% | 2 / 3 | 1 / 3 | 100 % |

1R1Y = 1R1B + 1Y1B

440V = 145V + 295V

THIS INDICATES THAT THE TRANSFORMER IS MAGNETICALLY BALANCED.IF THERE IS ANY INTER-TURN SHORT CKT THAT MAY RESULT IN THE SUM OF THE TWO VOLTAGES NOT BEING EQUAL TO THE APPLIED VOLTAGE.

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## II CABLE VOLTAGE DROP II

LT CABLES VOLTAGE DROP FORMULA –

IF YOU WANT VOLTAGE DROP IN PERCENTAGE % THEN FOLLOWING FORMULA USE.

$\sqrt{3}\ X\ IL\ X\ CABLE\ LENGTH\ X\ 100\ X\ (\ R\cos\emptyset + J\sin\emptyset\ )$ / LINE VOL X NO OF CABLE RUNS X 1000

HERE,

IL – LOAD CURRENT.

R – RESISTANCE OF CABLE.( Ω PER KM )

J – RECTANCE OF CABLE.( Ω PER KM )

NOTE - TAKE CABLE LENGTH IN MTR.

EXAMPLE :

LOAD IN KW – 1000KW.

LT CABLE SIZE – 300SQ.MM X 3.5C , A2XFY

CABLE LENGTH – 200 MTR.

LINE VOL – 415V.

RESISTANCE OF CABLE – 0.13Ω/KM.

REACTANCE OF CABLE – 0.0710Ω / KM.

CONSIDER COSØ – 0.8

FIRST WE CALCULATE LOAD CURRENT –

∴1000 KVA = 1.732 X 415 X 0.8

# ENGINEERING DETAILS

LOAD CURRENT = 1739.05 AMP

300 SQ.MM X 3.5C CABLE CURRENT CAPACITY 375AMPS ( IN GROUND )

∴ NO OF CABLE RUNS = LOAD CURRENT / CABLE CURRENT CAPACITY

∴ NO OF CABLE RUNS = 1739.05 / 375

∴ NO OF CABLE RUNS = 5 RUNS.

NOW CONVERT COSØ VALUE TO SINØ VALUE.

COSØ – 0.8

∴ $\emptyset = \cos^{-1} 0.8 = 36.87°$

$$\therefore \sin(36.87°) = 0.6$$

NOW PUT THE VALUE IN ABOVE FORMULA.

∴ % VOL. DROP =1.732 X 1739.05 X 200 X 100 X( 0.13 X 0.8 + 0.0710 X 0.6 ) / 415 X 5 X 1000

∴ % VOL. DROP = 4.25%

NOW WE CALCULATE VOLTAGE DROP IN VOLT

$\sqrt{3}$ *X IL X CABLE LENGTH X* ( $R \cos\emptyset + J \sin\emptyset$ ) / NO OF CABLE RUNS X 1000

∴ % VOL. DROP =1.732 X 1739.05 X 200 X( 0.13 X 0.8 + 0.0710 X 0.6 ) / 5 X 1000

∴ VOL. DROP = 17.66VOLT.

∴TALLY WITH % VOL. DROP = 415 X 4.25%

∴ TALLY WITH % VOL. DROP = 17.66VOLT.

---

❖ HOW TO CALCULATE ALUMINIUMXLPE INSULATIONLT CABLE SHORT CKT LEVEL IN kA ( Isc )

# ENGINEERING DETAILS

FORMULA : $$Isc = \frac{(0.094\ X\ CABLE\ DIA.IN\ Sq.mm)}{\sqrt{SHORT CKT.TIME\ IN\ SEC.}}$$

FOR EXAMPLE :-

CALCULATE 300 Sq.mm LT CABLE SHORT CKT. ( Isc ) CURRENT IN 1 SEC.

∴ PUT THE VALUE IN ABOVE FORMULA

$$\therefore Isc = \frac{(0.094\ X\ 300)}{\sqrt{1}}$$

$$\therefore Isc = 28.3\ kA(\text{ for 1 sec })$$

NOW WE CALCULATE SAME CABLE Isc FOR 2 SEC.

$$\therefore Isc = \frac{(0.094\ X\ 300)}{\sqrt{2}}$$

$$\therefore Isc = 20\ kA(\text{ for 2 sec })$$

- HOW TO CALCULATE COPPER LT XLPE INSULATIONCABLE SHORT CKT LEVEL IN kA ( Isc )

FORMULA : $$Isc = \frac{(0.143\ X\ CABLE\ DIA.IN\ Sq.mm)}{\sqrt{SHORT CKT.TIME\ IN\ SEC.}}$$

FOR EXAMPLE :-

CALCULATE 300 Sq.mm LT CABLE SHORT CKT. ( Isc ) CURRENT IN 1 SEC.

∴ PUT THE VALUE IN ABOVE FORMULA

$$\therefore Isc = \frac{(0.143\ X\ 300)}{\sqrt{1}}$$

$$\therefore Isc = 42.9\ \text{kA( for 1 sec )}$$

NOW WE CALCULATE SAME CABLE Isc FOR 2 SEC.

$$\therefore Isc = \frac{(0.143\ X\ 300)}{\sqrt{2}}$$

$$\therefore Isc = 30.34\ \text{kA( for 2 sec )}$$

NOTE : - WHICH VALUE WE HAVE USE 0.143 FOR COPPER & 0.094 FOR ALUMINIUM ?

ANS : - IT'S THE VALUE OF "k" WHICH IS DEPENDENT ON THE CABLE INSULATION , ALLOWABLE TEMPERATURE RISE UNDER FAULT CONDITION CONDUCTOR RESISTIVITY & HEAT CAPACITY & ABOVE CONSIDERED TYPICAL" k " VALUE OF XLPE CABLE AS PER IS 3043 ( TABLE 6 ).

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## ❖ MINIMUM BENDING RADIUS OF CABLES

MINIMUM BENDING RADIUS OF LT POWER CABLES. PVC OR XLPE CA BLE

FORMULA : AS PER IS - 1255

∴ MINIMUM BENDING RADIUS = 12 X CABLE DIAMETER. ( FOR MULTICORE )

∴ MINIMUM BENDING RADIUS = 15 X CABLE DIAMETER.( FOR SINGLECORE )

FOR EXAMPLE CALCULATE ABOVE 3.5C X 300Sq.mm LT STRIP ARMOURED CABLE BENDING RADIUS.

∴ MINIMUM BENDING RADIUS = 12 X 59.3mm

# ENGINEERING DETAILS

∴ MINIMUM BENDING RADIUS = 712 mm

∴ SO, DIAMETER OF ABOVE CABLE BENDING IS = 2 X 712 mm.

∴ SO, DIAMETER OF ABOVECABLE BENDING IS = 1424 mm.

MINIMUM BENDING RADIUS OF HT POWER CABLES.PVC OR XLPE CABLE

FORMULA : AS PER IS 1255

∴ MINIMUM BENDING RADIUS = 15 X CABLE DIAMETER.(FOR MULTICORE )

∴ MINIMUM BENDING RADIUS = 20 X CABLE DIAMETER.(FOR SINGLECORE )

MINIMUM BENDING RADIUS OF CONTROL CABLES.S

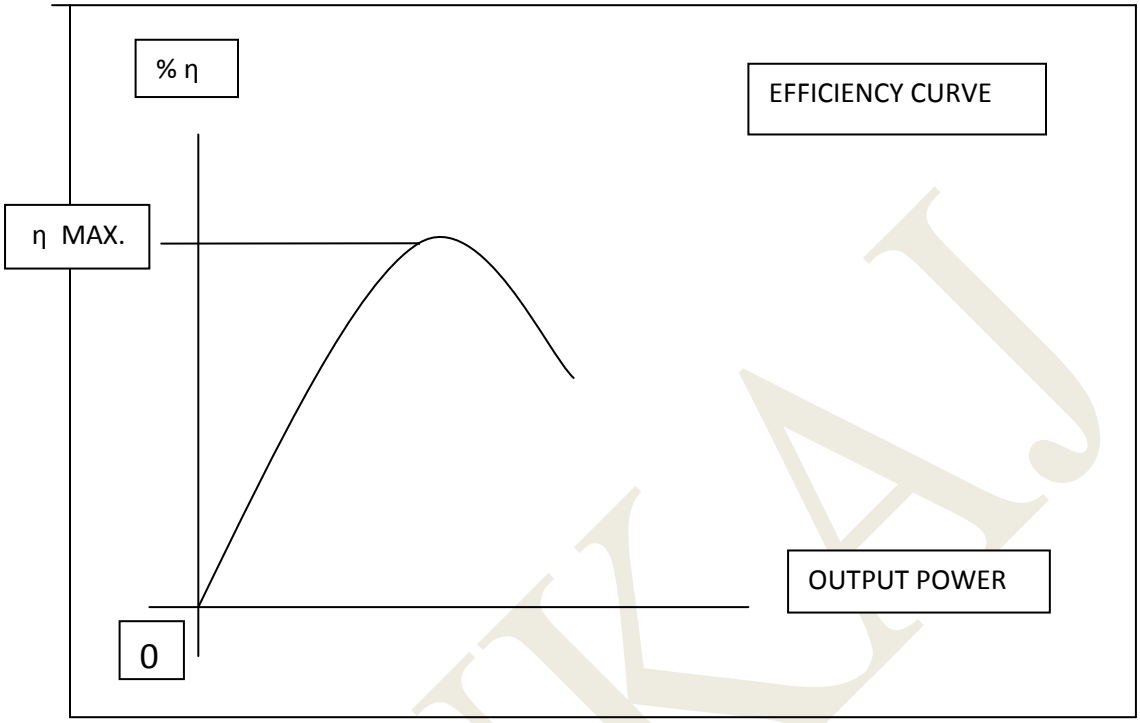
FORMULA :

∴ MINIMUM BENDING RADIUS = 10 X CABLE DIAMETER.

❖ WHAT IS MEAN BY EFFICIENCY OF MOTOR.?

THE RATIO BETWEEN MECHANICAL OUTPUT & ELECTRICAL INPUT.THE PERCENTAGE GIVEN INDICATES HOW EFFECTIVE THE MOTOR IS AT CONVERTING ELECTRICAL ENERGY TO MECHANICAL ENERGY.ALWAYS INDICATE % EFFICIENCY CURVE AS FOLLOWS.

NOTE = ALWAYS RUN EVERY ELECTRICAL EQUIPMENT IN ITS FULL EFFICIENCY OTHERWISE I2R LOSSES OCCURRED.

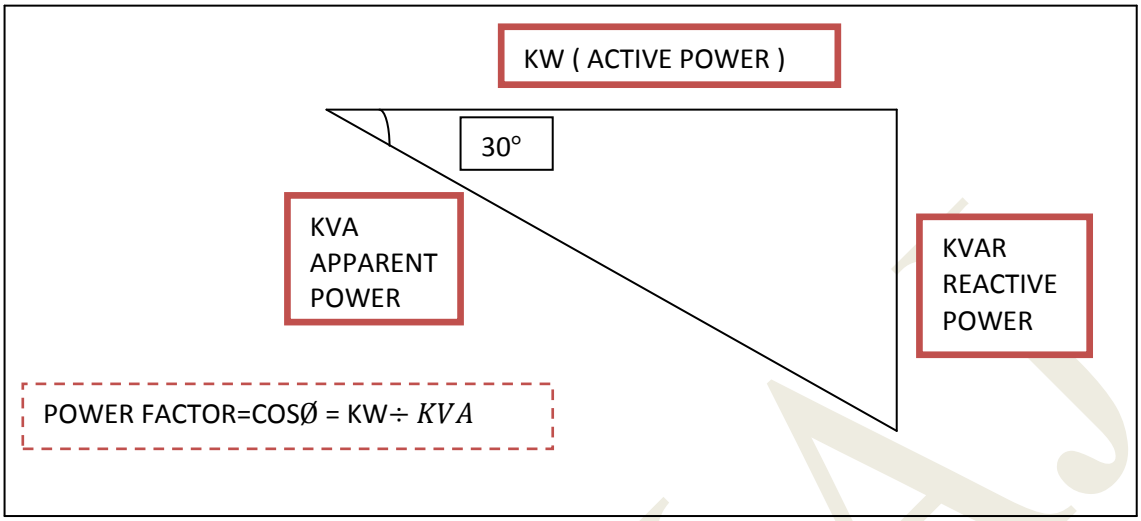



## ❖ POWER FACTOR BASICS ;

IN ALL DISTRIBUTION SYSTEMS THE MAJOR LOADS ARE RESISTIVE & INDUCTIVE. IN CASE OF PURE RESISTIVE LOADS, THE VOLTAGE V, CURRENT I,RESISTANCE R RELATIONS ARE LINEARLY RELATED.

ACTIVE POWER IS MEASURED IN KW, REACTIVE POWER IS MEASURED IN KVAR ( KILLO VOLT- AMPERE REACTIVE ). THE VECTOR SUM OF THE ACTIVE POWER & REACTIVE POWER MAKE UP THE TOTAL ( OR APPARENT ) POWER USED.TOTAL POWER ( OR APPARENT POWER ) IS MEASURED IN KVA.SEE FIGURE.

# ENGINEERING DETAILS




HOW TO CALCULATE KVAR CAPACITY OF CAPACITOR AS PER LOAD ?

EXAMPLE –

LOAD IN KW – 800KW

EXITING POWER FACTOR - Ø - 0.80 ( **tan Ø1** )

TARGETTED POWER FACTOR - .98 ( **tan Ø2** )

FORMULA

∴ LOAD KW ( P ) X ( **tan Ø1** X **tan Ø2** )

$\cos^{-1} 0.8$ = 36.86

**tan 36.86** = 0.750 ---------- **tan Ø1**

$\cos^{-1} 0.98$ = 11.48

**tan 11.48** = 0.2030 ---------- **tan Ø2**

$$\therefore P\ (\tan \emptyset 1 - \tan \emptyset 2)$$

$$\therefore 800\ (0.750 - 0.2030)$$

∴ REQUIRED CAPACITOR IN KVAR = 438 KVAR.

NOTE – USING ABOVE FORMULA IN BRACKET SHOWN WE HAVE CALCULATE MULTIPLYING FACTOR FOR CALCULATING THE SIZES OF CAPACITOR FOR POWER FACTOR IMPROVEMENT.

1. THE KVAR OF CAPACITOR WILL NOT BE SAME IF VOLTAGE APPLIED TO THE CAPACITOR & FREQUENCY CHANGES. SEE EXAMPLE BELOW.IT MEANS HOW TO CALCULATE AT PRESENT WHICH KVAR USED FROM CAPACITOR DUE TO VOLTAGE & FREQUENCY VARIATION.

EXAMPLE - 1

CAPACITOR NAME PLATES DETAILS = 16.7KVAR,3PHASE,440V,50Hz.

NOW ACTUAL SITE MEASURED VOLTAGE – 425V

MEASURED FREQUENCY = 48.5Hz.

FORMULA : -

∴ KVAr = ( fM / fR ) x ( VM / VR )$_2$ x KVAr

fM- MEASURED FREQUENCY.

fR-RATED FREQUENCY.

VM – MEASURED VOLTAGE.

VR – RATED VOLTAGE.

∴ KVAr = ( 48.5/50 ) X ( 425/440 )$_2$ X 16.7

∴ 15.11 KVAr.

CONCLUSION = ACTUAL CAPACITOR WORKS AT 15.11KVAr OUT OF 16.7KVAr.

EXAMPLE - 2

CAPACITOR NAME PLATES DETAILS = 16.7KVAR, 3PHASE,415V,50Hz.

NOW ACTUAL SITE MEASURED VOLTAGE – 425V

MEASURED FREQUENCY = 48.5Hz.

FORMULA : -

$\therefore$ KVAr = ( fM / fR ) x ( VM / VR )$^2$ x KVAr.

$\therefore$ KVAr = ( 48.5/50 ) X ( 425/415 )$^2$ X 16.7

$\therefore$ 16.98 KVAr.

CONCLUSION = ACTUAL CAPACITOR WORKS AT 16.98KVAr OUT OF 16.7KVAr.

---

2. CALCULATE RATED CURRENTOF CAPACITOR WITH RATED SUPPLY VOLTAGE & FREQUENCY.

FORMULA :

$\therefore$ Ic = KVAr X 1000 / ( $\sqrt{3}\ X\ Vl$ )

EXAMPLE : 1

16.7KVAr,3PHASE,440V,50Hz.CAPACITOR.

Ic = 16.7 X 1000 / ($\sqrt{3}$ X 440 )

Ic = 21.91 AMP.

EXAMPLE : 2

16.7KVAr,3PHASE,415V,50Hz.CAPACITOR.

Ic = 16.7 X 1000 / ($\sqrt{3}$ X 415 )

Ic = 23.23 AMP.

---

3. THE CURRENT OF CAPACITOR WILL NOT BE SAME IF VOLTAGE APPLIED TO THE CAPACITOR & FREQUENCY CHANGES.THE FOLLOWING EXAMPLE SHOWS HOW TO CALCULATE CAPACITOR CURRENT FROM THE MEASURED VALUE AT SITE.

FORMULA :

$$IM = IR \left( \frac{Vm \; X \; fm}{VR \; X \; fR} \right)$$

EXAMPLE : CONSIDER A CAPACITOR OF 16.7KVAr,440V,50Hz, 21.91 Amps, 3 PHASE CAPACITOR.

$$IM = 21.91 \left( \frac{425 \; X \; 48.5}{440 \; X \; 50} \right)$$

IM = 20.53Amps.

NOTE :- PLEASE BE ENSURE THAT THE MEASUREMENT IS DONE USING TRUE RMS CLAMP METER.

HOW TO CHECK CAPACITOR WITH AVO( AMMETER,VOLT & OHM )

& DIGITAL MULTIMETER )

ANS :- FIRST WE USE AVO METER TEST & FOLLOW THE PROCESS.

i. FIRST DISCONNECT &DISCHARGE SUSPECTED CAPACITOR.

ii. MAKE SURE CAPACITOR IS FULLY DISCHARGED.

iii. SELECT AVO METER ON OHM ( ALWAYS SELECT THE HIGHER RANGE OF OHMS )

iv. NOTE THAT THE FOLLOWING READINGS.

v. IF CAPACITOR INTERNALLY SHORT CIRCUITED METER SHOW VERY LOW RESISTANCE.

vi. IF CAPACITOR INTERNALLY OPEN CIRCUITED METER WILL NOT SHOW ANY DEFLECTION ON OHM METER SCREEN.

vii. IF CAPACITOR IN GOOD CONDITION IT WILL SHOW LOW RESISTANCE,AND THEN GRADUALLY INCREASES TOWARDS THE INFINITE.IT MEANS THAT CAPACITOR IS IN GOOD CONDITION.

% VOLTAGE RISE IN TRANSFORMER USING CAPACITOR/APFC PANEL.

$$\%\ VOLTAGE\ RISE = \frac{CAPACITOR\ KVAR}{TRAFO.KVA}\ X\ \%\ Z$$

EXAMPLE : -

TRAFO CAPACITY : - 1000 KVA.

TRAFO. % Z :- 4.72%

TRAFO. SEC. VOL :- 433 VOL.

APFC BANK KVAR RATING :- 438 KVAR.

∴ PUT THE VALUE IN ABOVE FORMULA

$$\%\ VOLTAGE\ RISE = \frac{438}{1000}\ X\ 4.72$$

∴ % VOLTAGE RISE = 2.07

∴ % VOLTAGE RISE = 2.07

IT MEANS WHEN FULL CAPACITORS ON THAT TIME TRAFO. SEC. VOLTAGE RISE 2.07% FROM RATED VOLTAGE.

∴ 433 X 2.07% = 8.96 VOLT.

∴ 433 + 8.96 = 441.96 VOLT.

----------X----------X---------- X --------

## ❖ JOINTING OF CONDUCTORS

IS: 3043-1987

ALL CROSSING OF CONDUCTORS IN THE MAIN EARTH GRID SHOULD BE JOINTED. COMPRESSION TYPE JOINTS MAY BE USED FOR STRANDED CONDUCTORS. NON- CONDUCTOR STRIP SHOULD BE DRILLED FOR A BOLT HAVING A DIAMETER GREATER THAN ONE-THIRD OF THE WIDTH OF THE STRIP.IF THIS DIAMETER WILL EXCEEDED ,THEN A WIDER FLAG SHOULD BE JOINTD TO THE STRIP.

ALUMINIUM TO ALUMINIUM JOINT – WHEN POSSIBLE JOINTS ON STRIP CONDUCTOR SHOULD BE ARC WELDED USING EITHER THE TUNGSTEN INNERT GAS ARC. (TIC ) OR METAL INNERT GAS ARC.( MIG )TECHNIQUES.OXY-ACETYLENE GAS WELDING OR BRAZING MAY ALSO BE USED.

ROUND & RECTANGULAR CONDUCTORS CAN BE JOINTED WITH BOLTED CLAMPS.WHEN MAKING A BOLTED TYPE JOINT,THE SURFACE OF THE ALUMINIUM SHOULD BE CLEANED THOROUGHLY BY WIRE BRUSHING AND GREASED OR AN APPROVED JOINTING COMPOUND APPLIED IMMEDIATELY TO BOTH MATCHING SURFACES. BOLTS SHOULD THEN BE TIGHTENED AND ALL EXCESS GREASE OR COMPOUND WIPED OFF AND DISCARDED.

# ENGINEERING DETAILS

TO ENSURE ADEQUETE CONTACT PRESSURE & AVOID OVERSTRESSING ,TORQUE SPANNERS SHOULD BE USED.

ALUMINIUME TO COPPER JOINT – JOINTS BETWEEN ALUMINIUM AND COPPER SHOULD BE OF THE BOLTED TYPE & BE INSTALLED IN THE VERTICAL PLANE AT A MINIMUM DISTANCE OF 150MM ABOVE GROUND LEVEL.

THE RATING SURFACE OF THE ALUMINIUM SHOULD BE CLEANED THOROUGHLY BY WIRED BRUSHING & GREASED OR AN APPROVED JOINING COMPOUND APPLIED AND THE COPPER TINNED. GREASE OR AN APPROVED JOINTING COMPOUND SHOULD BE APPLIED TO THE MELTING SURFACE OF THE ALUMINIUM.AFTER BOLT TIGHTENING BY TORQUE SPANNER,EXCESS GREASE OR COMPOUND SHOULD BE WIPED OFF & DISCARDED.THE JOINT MAY BE PROTECTED BY A BITUMASTIC PAINT.

COPPER TO COPPER JOINTING – THE FOLLOWING METHODS MAY BE USED.

1. BRAZING USING ZINC-FREE BRAZING MATERIAL WITH A MELTING POINT OF AT LEAST 600°C.
2. RIVETING AND SWEATING.
3. EXPLOSIVE WELDING.

---

IN INDIA WE USE SOLIDLY GROUNDED EARTHING SYSTEM. SOLIDLY GROUNDED SYSTEMS ARE USED IN LOW VOLTAGE APPLICATIONS AT 600VOLTS OR LESS. IN THIS EARTHING TO CONNECT GENERATOR OR TRANSFORMER NEUTRAL WITHOUT ANY RESISTANCE/REACTANCE. IN THIS TYPE DURING GROUND FAULT CURRENT IS IN THE RANGE OF 25 TO 100% OF THE SYSTEM THREE PHASE FAULT CURRENT,

---

DIFFERENCE BETWEEN SYSTEM EARTHING/GROUNDING&EQUIPMENT EARTHING/EARTHING ?

EARTHING ASSOCIATED WITH CURRENT CARRYING CONDUCTOR IS NORMALLY ESSENTIAL TO THE SECURITY OF THE SYSTEM & IS GENERALLY KNOWN AS SYSTEM EARTHING/GROUNDING.

# ENGINEERING DETAILS

WHILE EARTHING OF NON-CURRENT CARRYING METAL WORK & CONDUCTOR IS ESSENTIAL TO THE SAFETYOF HUMAN LIFE,ANIMALS & PROPERTY,& IS GENERALLY KNOWN AS EQUIPMENT EARTHING/EARTHING.

FOR EXAMPLE : - TRANSFORMER/GENERATOR NEUTRAL EARTHING IS KNOWN AS SYSTEM EARTHING/GROUNDING.& TRANSFORMER / GENERATOR BODYEARTHING IS KNOWN AS EQUIPMENT EARTHING/EARTHING.

EARTHING EXAMPLES :

- PLATE TYPE EARTHING

PLATE ELECTRODES SHALL BE OF THE SIZE AT LEAST 60cm X 60cm. PLATES ARE GENERALLY OF CAST IRON NOT LESS THAN 12MM THICK & PREFERABLY RIBBED.THE EARTH CONNECTIONS SHOULD BE JOINED TO THE PLATE AT NOT LESS THAN TWO SEPARATE POINTS. PLATE ELECTRODES,WHEN MADE OF GI OR STEEL,SHALL BE NOT LESS THAN 6.3MM IN THICKNESS. PLATE ELECTRODES OF CU. SHALL BE NOT LESS THAN 3.15MM IN THICKNESS.

PLATE ELECTRODE SHALL BE BURIED SUCH THAT ITS TOP EDGE IS AT A DEPTH NOT LESS THAN 1.5 MTR.FROM THE SURFACE OF THE GROUND

PLATE TYPE EARTHING :

PLATE SIZE :- 600 X 600 X 6MM GI

FAULT CURRENT :- 65KA FOR S1 SEC.

SOIL RESISTIVITY :- 100Ω-MTR.

FORMULA :

FIRST WE CALCULATE CURRENT DENSITY.( Id )

$\therefore Id = 7.57 \times 1000 / \sqrt{\rho X t}$ ---------- ①

NOTE - GET ANSWER IN AMP/SQ.MTR.

SECOND WE CALCULATE PLATE SURFACE AREA.

∴A = 2 X L X W ( FOR PLATE TYPE & FOR PIPE TYPE USE $2\pi rL$ )---------- ②

L – PLATE LENGTH.

W – PLATE WIDTH.

NOTE – GET ANSWER IN SQ.MTR.

THIRD WE CALCULATE MAXIMUM CURRENT DISSIPATED BY ONE EARTHING PLATE/PIT.

∴K = Id X A ---------- ③

Id = CURRENT DENSITY.

A = PLATE/PIT AREA.

NOTE – GET ANSWER IN AMPS.

FOURTH WE CALCULATE EACH EARTHING PLATE RESISTANCE.

∴R = $\rho$ / $A\sqrt{3}.14$ / $A$ ---------- ④

NOTE : - ' $\rho$ 'MEANS Rho & Rho MEANS SOIL RESISTIVITY.

'$A$ ' MEANS AREA OF BOTH OF THE PLATES.

NOTE – GET ANSWER IN OHMS ( Ω ).

FIFTH WE CALCULATE NO OF PLATES REQUIRED AS PER FAULT CURRENT.

∴NO OF PITS =FAULT CURRENT / K ---------- ⑤

NOTE – GET ANSWER IN NOS.

FINALLY WE CALCULATE TOTAL EARTHING RESISTANCE.

∴EACH EARTHING PLATE RESISTANCE / NO OF PITS.

NOW WE SOLVE PLATE TYPE EARTHING EXAMPLE USING ABOVE SAID FORMULA.

# ENGINEERING DETAILS

∴Id = 7.57 X 1000 / $\sqrt{\rho X t}$ ---------- ①

∴ Id = 7.57 X 1000/ $\sqrt{100X\ 1}$

∴ Id = 757 AMP/SQ.MTR.

∴A = 2 X L X W ---------- ②

∴ A = 2 X 0.6 X 0.6

∴ A = 0.72SQ.MTR. ( AREA OF BOTH SIDE OF THE PLATES )

∴K = Id X A ---------- ③

∴ K = 757 X 0.72

∴ K = 545.04 AMP.

∴R = $\rho$ / A$\sqrt{3.14}$ / A ---------- ④

∴ R = 100 / 0.72 X $\sqrt{3.14}$ / 0.72

∴ R = 138.89 X 2.088

∴ R = 290.00 Ω ( EACH EARTHING PLATE RESISTANCE )

∴NO OF PITS =FAULT CURRENT / K ---------- ⑤

∴NO OF PITS = 65K / 545.04

∴ NO OF PITS = 119.25 NOS.

$$\therefore \text{TOTAL EARTHING RESISTANCE} = \frac{\textit{EACH EARTHING PLATE RESISTANCE}}{\textit{NO OF PITS}}$$

∴ 290 / 119

∴ TOTAL EARTHING RESISTANCE = 2.43 Ω

# ENGINEERING DETAILS

NOTE :- SAME FORMULA USE FOR PIPE TYPE EARTHING.

## HOW TO CALCULATE CROSS SECTION AREA OF EARTHING CONDUCTOR AS PER FAULT CURRENT.

FORMULA :

CROSS SECTION AREA OF CONDUCTOR ( A ) = If X $\sqrt{t}$ / K

WHERE – If – FAULT CURRENT.

t - TIME IN SEC.

K – MATERIAL CONSTANT.

STRIP MATERIAL - GI

NOTE :- MATERIAL CONSTANT FOR CU – 205, ALUMINIUM – 126, GI – 80

EXAMPLE –

FAULT CURRENT – 65 kA

t – 1 SEC.

PUT THE VALUE IN ABOVE FORMULA.

∴ A = 65000 X $\sqrt{1}$ / 80

∴A = 812SQ.MM

∴ 50 X 6MM GI STRIP = 300SQ.MM OF EACH STRIP

∴ SO WE REQUIRED NO OF STRIPS = 812 / 300

∴ SO WE REQUIRED NO OF EARTHING STRIPS = 3NOS.

FACTORS AFFECTING ON GROUND LEVEL.

# ENGINEERING DETAILS

- LENGTH / DEPTH OF THE GROUND ELECTRODE= DOUBLE THE LENGTH,REDUCE GROUND RESISTANCE BY UP TO 40% ONLY.
- DIAMETER OF THE GROUND ELECTRODE = DOUBLE THE DIAMETER,REDUCE GROUND RESISTANCE BY ONLY 10%.
- NUMBER OF GROUND ELECTRODE = THIS IS VERY EFFECTIVE METHOD. IN THIS METHOD ADD ADDITIONAL ELECTRODE IN PARALLEL.

## ❖ PIPE TYPE EARTHING

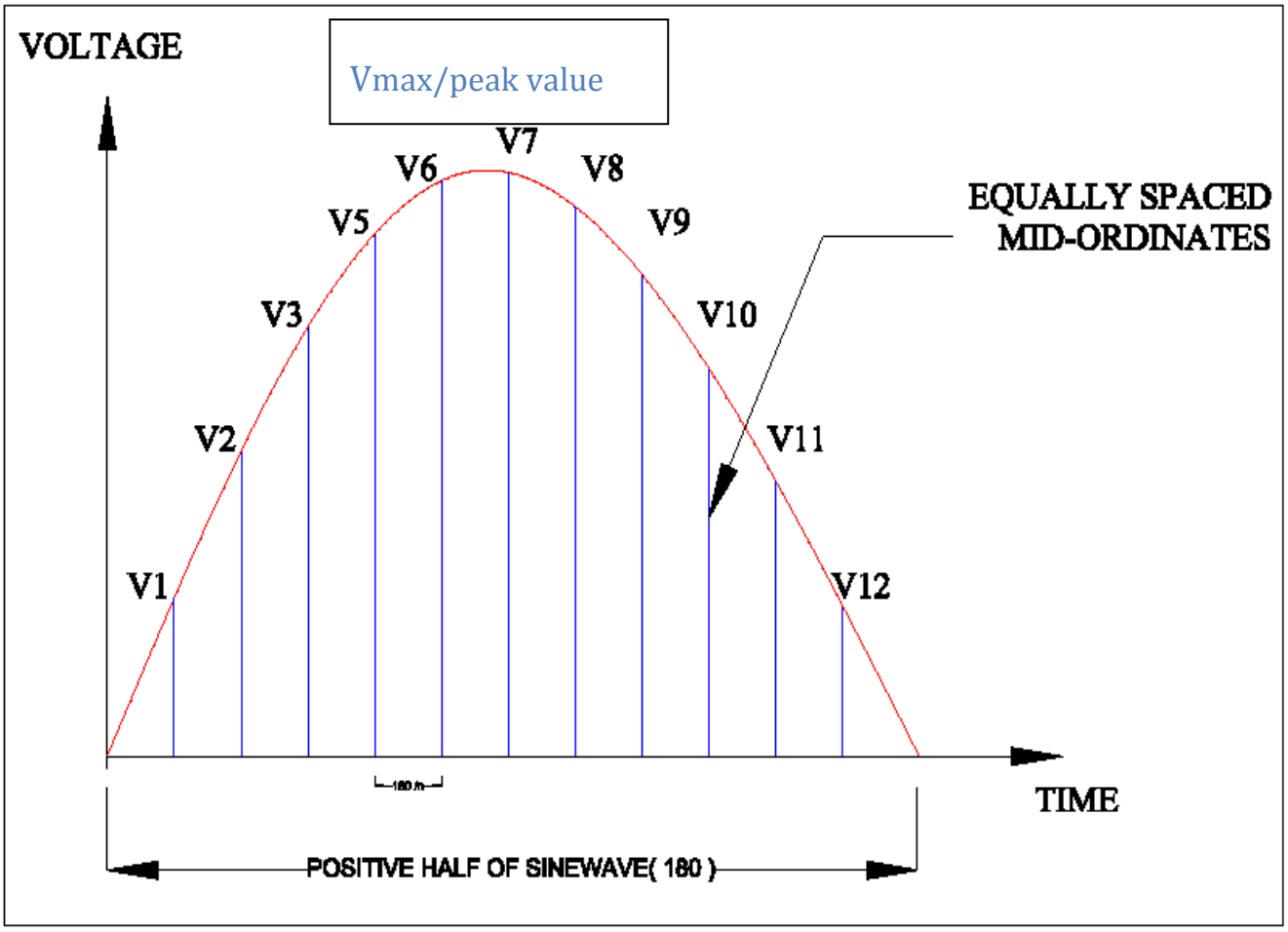
PIPES MAY BE OF CAST IRON OF NOT LESS THAN 100MM DIAMETER,2.5 TO 3 MTR. LONG & 13MM THICK,SUCH PIPES CANNOT BE DRIVEN SATISFACTORILY & MAY,THEREFORE,BE MORE EXPENSIVE TO INSTAL THAN PLATES FOR THE SAME EFFECTIVE AREA.ALTERNATIVELY,MILD STEEL WATER-PIPES OF 38 TO 40MM DIAMETER ARE SOMETIMES EMPLOYED. THESE CAN BE DRIVEN BUT ARE LESS DURABLE THAN COPPER RODS.

## ARTIFICIAL TREATMENT OF SOIL ( AS PER IS 3043 )

MULTIPLE RODS,EVEN IN LARGE NUMBER,MAY SOMETIME FAIL TO PRODUCE AN ADEQUETE LOW RESISTANCE TO EARTH. THIS CONDITION ARISES IN INSTALLATIONS INVOLVING SOILS OF HIGH RESISTIVITY. THE ALTERNATIVE IS TO REDUCE THE RESISTIVITY OF THE SOIL IMMEDIATELY SURROUNDING THE EARTH ELECTRODE. TO REDUCE THE SOIL RESISTIVITY ,IT IS NECESSARY TO DISSOLVE IN THE MOISTURE,NORMALLY CONTAINED IN THE SOIL,SOME SUBSTANCE WHICH IS HIGHLY CONDUCTIVE IN ITS WATER SOLUTION. THE MOST COMMONLY USED SUBSTANCES ARE SODIUME CHLORIDE ( NaCl ), ALSO KNOWN AS COMMON SALT, CALCIUME CHLORIDE ( $CaCl_2$ ),SODIUME CARBONET ( $Na_2CO_3$ ), COPPER SULPHATE ( $CuS_4$ ), SALT, AND SOFT COKE, AND SALT & CHARCOAL IN SUITABLE PROPORTIONS.

# ENGINEERING DETAILS

## RMS




THE TERM 'RMS' STANDS FOR " ROOT MEAN SQUARED ". MOST BOOKS DEFINE THIS AS THE "AMOUNT OF AC POWER THAT PRODUCES THE SAME HEATING EFFECT AS AN EQUIVALENT DC POWER."

FOR CALCULATION IS THE SAME FOR BOTH HALVES OF AN AC WAVEFORM,SO WE CONSIDER ONLY THE POSITIVE HALF CYCLE.THE POSITIVE HALF OF THE WAVEFORM IS DIVIDED UP INTO ANY NUMBER OF " n " EQUAL PORTIONS OR MID-ORDINATES & THE MORE MID-ORDINATES THAT ARE DRAWN ALONG THE WAVEFORM,THE MORE ACCURATE WILL BE THE FINAL RESULT.

# ENGINEERING DETAILS

NOTE :- IN AC SUPPLY WE HAVE CONSIDER ONLY HALF CYCLE FOR TAKING AVERAGE,BECAUSE POSITIVE HALF CYCLE VALUE IS EQUAL TO NEGATIVE HALF CYCLE VALUE, SO TOTAL IS ZERO.SO WE CONSIDER ONLY HALF CYCLE.

WHAT IS ACTUAL WORD TO WORD MEANING OF RMS ????

MID-ORDINATE VALUE OF A WAVEFORM ( MEANS V1,V2,V3...Vn )IS MULTIPLID BY ITSELF( SQUARED ) & ADDED TO THE NEXT. THIS GIVES US THE "SQUARE" PART OF THE RMS VOLTAGE EXPRESSION.NEXT THIS SQUARED VALUE IS DIVIDED BY THE NUMBER OF MID-ORDINATES USED TO GIVE US THE MEAN PART OF THE RMS VOLTAGE EXPRESSION.FINALLY,THE SQUARE ROOT OF THE MEAN VALUE IS FOUND TO GIVE US THE ROOT PART OF THE RMS VOLTAGE EXPRESSION.

$$V_{RMS} = \sqrt{\frac{\text{SUM OF MID-ORDINTE ( VOLTAGES )}^2}{\text{NUMBER OF MID-ORDINATES}}}$$

ORAS PER ABOVE DIAGRAM

$$V_{RMS} = \sqrt{\frac{V_1^2 + V_2^2 + V_3^2 + V_4^2 + V_5^2 + V_6^2 + V_7^2 + V_8^2 + V_9^2 + V_{10}^2 + V_{11}^2 + V_{12}^2}{12}}$$

NOTE :- ABOVE BOTH FORMULA FINAL ANSWER GET 0.707

# ENGINEERING DETAILS

RMS WAVEFORM IS AN AC WAVEFORM.RMS VOLTAGE IS THE DC EQUIVALENT OF AC WAVEFORM,THEN WE KNOW THAT BOTH WAVEFORMS GIVE OFF THE SAME AMOUNT OF POWER IN A CIRCUIT.RMS VOLTAGE IS THE DC EQUIVALENT VOLTAGE.

TODAY'S MULTIMETER SHOWS RMS READING MEANS WHEN METER SHOWS 230V ( PHASE TO NEUTRAL VOLTAGE ). 230VOL IS RMS VOLTAGE & ACTUAL AC VOLTAGE IS PRESENT 230V / 0.707 = 325 VOLTS

OR

AC VOLTAGE IS PRESENT 230V * $\sqrt{2}$ = 325 VOLTS.

WHERE TO COME $\sqrt{2}$

$\therefore$ PEAK VALUE = $\frac{Vmax}{VRms}$

$\therefore$ PEAK VALUE = $\frac{Vmax}{0.707 * Vmax}$

$\therefore$ $VR_{ms}$ = PEAK TO PEAK VOLTAGE $\times$ 0.707,SO WE WRITE $VR_{ms} = 0.707 \times V_{max}$

$\therefore$ PEAK VALUE = $\frac{1}{0.707}$

$\therefore$ PEAK VALUE = 1.414 ( $\sqrt{2}$ )

NOTES :- Vmax MEANS MAXIMUM VALUE OF ABOVE POSITIVE HALF CYCLE.

MEANS, DC 230 VOL. = AC RMS VOL. IS 230V & IS PEAK VOL. IS 325 VOL.

PEAK VALUE/CREST VALUE/ Vmax : - THE MAXIMUM VALUE OF ( PEAK OR AMPLITUDE ) OF AN ALTERNATING QUANTITY IS CALLED PEAK VALUE.

FORMULA : -

NOTE : - RMS VOLTAGE IS ALSO CALLED EFFECTIVE VOLTAGE IS BECAUSE IT IS JUST AC RMS AS EFFECTIVE AS DC VOLTAGE.

VRms = 0.707 Vmax

Vavg = 0.636 Vmax.

FORM FACTOR : - THE FORM FACTOR OF AN ALTERNATING QUANTITY IS DEFINED AS THE RATIO OF ITS RMS VALUE TO ITS AVERAGE VALUE.

$\therefore$ FORM FACTOR = $\frac{VRms}{Vavg}$

$\therefore$ FORM FACTOR = $\frac{0.707\ Vmax}{0.636\ Vmax}$

$\therefore$ FORM FACTOR = $\mathbf{1.11}$ ( UNIT LESS ) DUE TO THIS REASON WE DEVELOP VOLTAGES MULTIPLE OF 11KV/22KV/33KV...& SO ON.

## ❖ LIGHTNING ARRESTOR

WE USE LIGHTNING ARRESTOR TO PROTECT THE INSULATION OF ELECTRICAL POWER SYSTEMS & TELECOMMUNICATION SYSTEMS. NORMALLY LIGHTNING ARRESTOR GIVES US IMPULSE SURGE,SWITCHING SURGE & POWER FREQUENCY WITHSTAND SURGE PROTECTION.

WHAT IS IMPULSE SURGE ?

ANS : - DURING SHORT CIRCUIT OF PH-PH OR PH-N THIS TYPE OF SURGE GENERATE.

WHAT IS SWITCHIG SURGE ?

ANS :- WHEN NO LOAD LINE IS SUDDENLY SWITCHED ON,THE VOLTAGE ON THE LINE BECOMES TWICE OF NORMAL SYSTEM VOLTAGE.THIS VOLTAGE IS TRANSIENT IN NATUTRE. WHEN A LOADED LINE IS SUDDENLY SWITCHED ON/OFF OR INTERRUPTED,VOLTAGE ACROSS THE LINE ALSO BECOMES HIGH ENOUGH.

POWER FREQUENCY WITHSTAND SURGE :- IN THIS CASE VOLTAGE RISE BUT FREQUENCY DOES NOT RISE.

LA CALCULATIONS: -

# ENGINEERING DETAILS

HOW TO CALCULATE SUBSTATION TYPE , POLE MOUNTED 11KV / 22KV LA VOLTAGE RATINGS?

ANS : - FIRST WE CALCULATE 22KV LA VOLTAGE RATINGS.ALWAYS CONSIDER HSV ( HIGHEST SYSTEM VOLTAGE ) TO CALCULATE LA RATINGS.

∴ FOR 11000V HSV IS 12000V & 22000V HSV IS 24000V

FIRST WE CALCULATE 22KV SYSTEMS LA VOLTAGE RATINGS.

∴ PER PHASE VOLTAGE = $\frac{24}{\sqrt{3}}$ ( $\sqrt{3}$ DIVIDE FOR CALCULATE PHASE VOL. )

∴ PHASE VOLTAGE = 13.85KV

∴ $13.85 \times \sqrt{2}$ ( $\sqrt{2}$ TAKEN FOR CALCULATE RMS VOLTAGE.)

∴ 19.593 KV

∴ SO WE REQUIRED 19.59KV LIGHTNING ARRESTROR FOR 22KV SUPPLY VOLTAGE.

SECOND WE CALCULATE 11KV SYSTEMS LA VOLTAGE RATINGS.

∴ PER PHASE VOLTAGE = $\frac{12}{\sqrt{3}}$ ( $\sqrt{3}$ DIVIDE FOR CALCULATE PHASE VOL. )

∴ PHASE VOLTAGE = 6.928KV

∴ $6.928 \times \sqrt{2}$ ( $\sqrt{2}$ TAKEN FOR CALCULATE RMS VOLTAGE.)

∴ 9.796 KV

∴ SO WE REQUIRED 9.796KV LIGHTNING ARRESTROR FOR 11KV SUPPLY VOLTAGE.

# ENGINEERING DETAILS

## ❖ WHAT IS SWITCHING STATION ?

SWITCHING STATION IS AN INTERMEDIATE STATION BETWEEN TWO OTHER SUB-STATIONS OR BETWEEN SUBSTATION AT LOAD END & GENERATING STATION.AT SWITCHING STATION INCOMING POWER LINE & OUTGOING POWER LINES HAVE SAME LEVEL OF VOLTAGE,IT MEANS THERE IS NO TRANSFORMER TO STEPDOWN THE VOLTAGE TO CONNECT THE LOAD.

SWITCHING STATIONS ARE CREATED JUST PURPOSE OF CONTROLLING IMPORTANT PARAMETERS IN POWER SYSTEM & CONTROL OF VOLTAGE RISE DUE TO CAPACITIVE EFFECT OR VOLTAGE DROP DUE TO REACTIVE EFFECT OR BOTH.

## FUSE

FUSES BREAK A CIRCUIT BY CONTROLLED MELTING OF THE FUSE ELEMENT,WHEN A CURENT EXCEEDS A GIVEN VALUE FOE A CORRESPONDING PERIOD OF TIME.

THE STANDARDS DEFINE TWO TYPES OF FUSES.

TYPE – 1 INTENDED FOR DOMESTIC USE.

TYPE – 2 INTENDED FOR INDUSTRIAL USE.

THE MAIN DIFFERENCE BETWEEN DOMESTIC & INDUSTRIAL FUSES ARE THE NOMINAL VOLTAGES AND CURRENT LEVELS & THEIR FAULT CURRENT BREAKING CAPABILITY.

THE CONDITIONS OF FUSING OF A FUSE ARE DEFINED BY STANDARDS ACCORDING TO THEIR CLASS.

CLASS " gG " FUSE – THIS TYPE OF FUSE PROVIDES PROTECTION AGAINST OVERLOAD & SHORT CIRCUIT.

CLASS " gM " FUSE – THIS TYPE OF FUSE PROVIDES PROTECTION AGAINST SHORT CIRCUIT ONLY & NOT FOR OVERLOAD PROTECTION. A SEPARATE THERMAL TYPE RELAY IS ALWAYS NECESSARY WHEN USING " gM " FUSE.

CLASS " aR " , " gR " , gS " FUSE – THIS IS SEMICONDUCTOR FUSES & USE FOR V3F, SOFT STARTERS ETC.

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# ENGINEERING DETAILS

## HARMONICS

HARMONICS ARE PRESENT IN ALL INDUSTRIAL,COMMERCIAL & RESIDENTIAL INSTALLATIONS. HARMONICS ARE CAUSED BY NON-LINEAR LOADS ( $N_{LL}$ ). A LOAD IS SAID TO BE NON-LINEAR WHEN THE CURRENT IT DRAWS DOES NOT HAVE THE SAME WAVE FORM AS THE SUPPLY VOLTAGE.

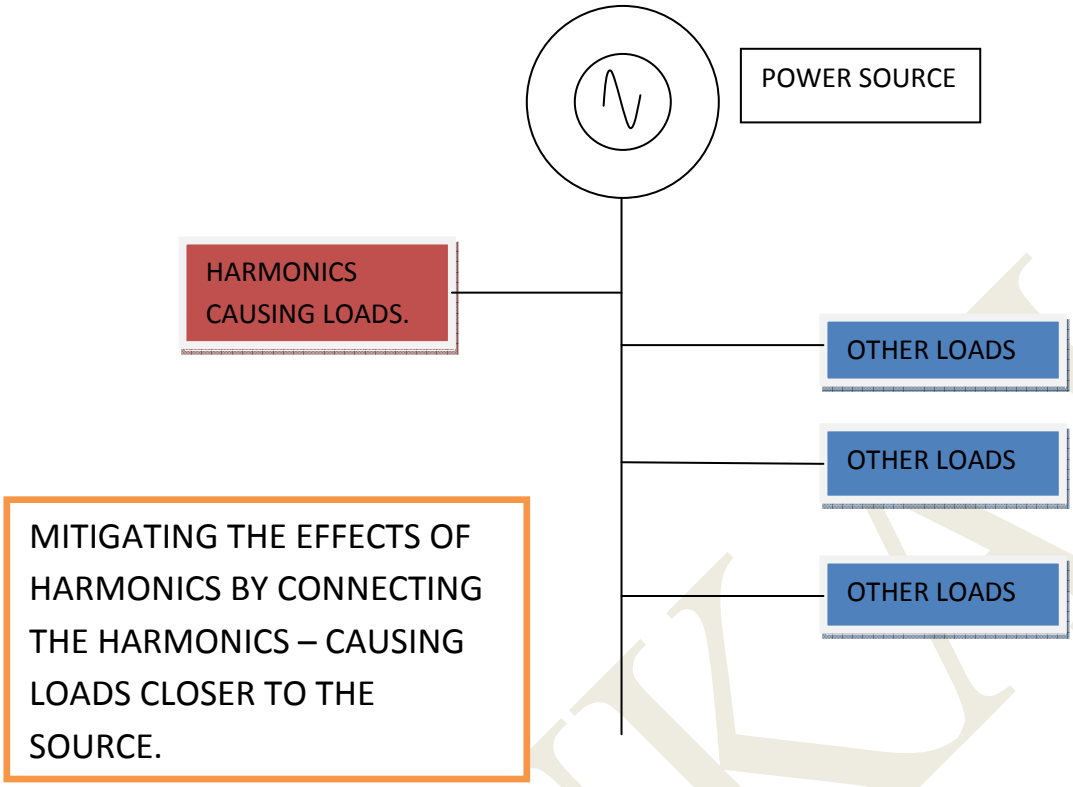
IN COMMON DISCUSSION ABOUT HARMONICS,THE DIFFERENCE BETWEEN CURRENT & VOLTAGE HARMONICS IS RARELY ADRESSED. WHILE CURRENT & VOLTAGE HARMONICS ARE RELATED& THEIR EFFECTS ARE DIFFERENT.

CURRENT HARMONICS ARE CAUSED BY NON-LINEAR LOADS SUCH AS THYRISTOR DRIVES,INDUCTION FURNACES,ETC.CURRENT HARMONICS DO NOT AFFECT THE REMINDER OF THE LOADS IN THE SYSTEM WHICH ARE LINEAR. THEY ONLY IMPACT THE LOADS WHICH ARE CAUSING THEM i.e NON-LINEAR LOADS.

VOLTAGE HARMONICS ARE CAUSED BY THE CURRENT HARMONICS WHICH DISTORT THE VOLTAGE WAVEFORM.THESE VOLTAGE HARMONICS AFFECT THE ENTIRE SYSTEM,NOT JUST THE LOADS WHICH ARE CAUSING THEM.

THEIR IMPACT DEPENDS ON THE DISTANCE OF THE LOAD CAUSING THE HARMONICS FROM THE POWER SOURCE.

# ENGINEERING DETAILS




## EXAMPLES OF NON-LINEAR LOAD ( $N_{LL}$ )–

1. INDUSTRIAL EQUIPMENTS – WELDING M/C , ARC FURNACES, INDUSTRIAL FURNACES, RECTIFIERS,VFD etc.
2. OFFICE EQUIPMENTS – PC's,XEROX M/C, FAXMACHINES,UPS, etc.
3. HOUSEHOLD APPLIANCES – TELE-VISION,MICROWAVE OVEN, FLUROCENT LIGHTING etc.
4. SATURATION OF EQUIPMENT ( ESSENTIALLY TRANSFORMERS MAY ALSO CAUSE NON-LINEAR CURRENTS.

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## HT PANELS INFORMATION

1. ICOG PANEL ( INCOMING & OUTGOING PANEL ) – IN THIS PANEL CONSIST OF ONE VCB ( 11KV/22KV/33KV FOR INPUT/OUTPUT ) & PROTECTION RELAY.
2. LBS – LOAD BREAK SWITCH

# ENGINEERING DETAILS

## LT PANELS INFORMATION

TYPES OF PANELS.

1. MAIN LT PANEL
2. POWER CONTROL CENTER ( PCC )
3. ISOLATION PANEL
4. APFC / RTPFC PANEL
5. POWER DISTRIBUTION BOARD ( PDB )
6. MOTOR CONTROL CENTER ( MCC )
7. CHANGEOVER PANEL ( C / O )
8. AUTO MAINS FAILURE ( AMF PANEL )
9. SYNCHRONIZING PANEL ( SYNC. PANEL )

## INFORMATION ABOUT ACB.

ACB ( ANSI CODE – 52 )

FIXED TYPE :- IN THIS TYPE BREAKER RACK IN / RACK OUT IS NOT POSSIBLE.

DRAW OUT : - IN THIS TYPE BREAKER RACK IN / RACK OUT IS POSSIBLE FOR MAINTANANCE.

ELECTRONIC DRAW OUT ( EDO ) : - IN THIS TYPE BREAKER USE WITH SPRING CHARGING MOTOR,UNDER VOLTAGE COIL,SHUNT COIL & CLOSING COIL.

MECHANICAL DRAW OUT BREAKER ( MDO ) : - IN THIS TYPE BREAKER DOES NOT USE SPRING CHARGING MOTOR,UNDERVOLTAGE COIL,SHUNT COIL & CLOSING COIL .

LT BREAKERS FOLLOWING ARE THE TRIP TYPES.

1. LSIG TYPE : - L = LONG TIME ( OVER LOAD TRIP ) , S = SHORT TIME ( SHORT CIRCUIT TRIP ) , I = INSTANTANEOUS TRIP , G = GROUND/EARTH FAULT TRIP.

2. LSIA TYPE : - LSI ARE THE SAME AS ABOVE. THE "A" MEANS THAT THE GROUND FAULT FUNCTION IS AN "ALARM" ONLY & WILL NOT TRIP THE BREAKER.

NOTE : - WE CAN ALSO USE ONLY LSI,LI TRIP TYPES AS PER OUR REQUIREMENTS.

BREAKER OPERATING POSITIONS :

- SERVICE POSITION : - IN THIS POSITION MAIN & AUXILLARY CONTACTS CONNECTED.
- TEST POSITION : - IN THIS POSITION ONLY AUXILLARY CONTACTS CONNECTED.& MAIN CONTACTS DISCONNECTED.
- ISOLATED POSITION : - IN THIS POSITION BOTH MAIN & AUXILLARY CONTACTS FULLY DISCONNECTED.

ACB FUNCTIONS : -

a) NO LOAD LINE BIAS – MEANS EITHER SIDE OF ACB USED FOR INCOMING/OUTGOING.

b) ANTI PUMPING – THE FUNCTION OF ANTI PUMPING RELAY IS TO CUT OFF THE SUPPLY TO CLOSING COIL IN CASE OF TNC ( TRIP NEUTRAL CLOSE ) SWITCH SPRING FAILURE & PREVENT CB HUNTING EFFECT ( MEANS CONTINUOUS CLOSING,OPENING OPERATION ) & PERSON NEEDS TO ATTEND THE PROBLEM.

NOTE : - ANSI CODES 94 OR EVEN 52 CAN BE USED.

ACB NORMALLY OPEN CONTACTS ( NO ) – ANSI CODE – 52a

ACB NORMALLY CLOSE CONTACTS ( NC ) - ANSI CODE – 52b

SWITCHGEARS

IN ELECTRICAL SYSTEM SWITCHGEAR IS THE COMBIBATION OF DISCONNECT SWITCHES,FUSES,CIRCUIT BREAKERS USED TO CONTRAL,PROTECT & ISOLATE ELECTRICAL EQUIPMENT.SWITCHGEARS IS USED BOTH TO DE-ENERGIZE EQUIPMENT TO ALLOW WORK TO BE DONE & CLEAR FAULTS DOWNSTREAM.

# ENGINEERING DETAILS

INSULATING RUBBER MATS FOR ELECTRICAL PURPOSES SPECIFICATION AS PER IS – 15652 : 2006

FOUR CLASSES OF MATS,COVERED UNDER THIS STANDARD & DIFFERENT IN ELCTRICAL CHARACTERISTICS FOR DIFFERENT USE VOLTAGES ARE DISIGNATED AS GIVEN FOLLOWING TABLES.

CLASSES & MAXIMUM USE VOLTAGES.

| SERIAL NUMBER | MAT CLASS | Ac ( rms ) KV | Dc VOLTAGE |
|---|---|---|---|
| 1 | A | 3 . 3 | 2 4 0 |
| 2 | B | 1 1 | 2 4 0 |
| 3 | C | 3 3 | 2 4 0 |
| 4 | D | 6 6 | 2 4 0 |

THICKNESS OF MATS FOR DIFFERENT CLASSES.

| SERIAL NUMBER | CLASS OF MAT | THICKNESS( mm ) | TOLERENCE IN % |
|---|---|---|---|
| 1 | A | 2 . 0 0 | +/- 10 |
| 2 | B | 2 . 5 0 | +/- 10 |
| 3 | C | 3 . 0 0 | +/- 10 |
| 4 | D | 3 . 5 0 | +/- 10 |

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# ENGINEERING DETAILS

## GENERAL INFORMATION ABOUT CURRENT TRANSFORMER

WHY WE 'GROUND' CT SECONDARY LEADS ( S2 ) ?

ANS : - IN LV( LOW VOLTAGE <1000 V ) INSTALLATIONS IT IS RECOMMENDED THAT THE CURRENT TRANSFORMER SECONDARY LEADS ( S2 ) ARE GROUNDED AS PROTECTION AGAINST STATIC VOLTAGE OR INSULATION FAILURE.

DIFFERENCE BETWEEN NORMAL TRANSFORMER & CURRENT TRANSFORMER.?

OR

WHY CT SECONDARY SHOULD NOT OPEN & MUST BE SHORT WITH LINK OR AMMETER ?

ANS : - IN NORMAL TRAFO. PRIMARY CURRENT DEPENDS ON SECONDARY LOAD CURRENT, WHEN LOAD INCREASE PRIMARY CURRENT ALSO INCREASE. WHEN LOAD DECREASE UPTO ZERO, THEN PRIMARY CURRENT ALSO DECREASE UPTO ZERO. THIS IS THE MAIN REASON OF NORMAL TRAFO SECONDARY SIDE IN OPEN CONDITION NO HARMFULL FOR PERSON.

BUT IN CURRENT TRANSFORMER PRIMARY CURRENT IS NOT DEPEND UPON SECONDARY SIDE & THIS IS THE MAIN REASON CT SEC. IS ALWAYS CONNECTED IN EARTHING.

FOLLOWING ARE THE MAIN FOUR TYPES OF INSTRUMENT TRANSORMER ( CT )

1. RING TYPE : - THIS TYPE OF CT RECTANGULAR OR CIRCULAR IN A SHAPE,& CONDUCTOR HAS TO BE DISMENTLEDAT ONE END TO FIT THE CT.
2. SPLIT CORE : - IN THIS TYPE CT SPLITS INTO TWO PIECES SO THAT IT CAN BE FITTED AROUND THE CONDUCTOR.SPLIT-CORE DESIGNED FOR USE IN EXISTING INTALLATIONS IN WHICH DOES NOT POSSIBLE TO DISCONNECT ONE END OF THE CABLE OR BUSBAR. A SPLIT CORE CT HAS TWO MAIN SEGMENTS ONE IS MAIN SEGMENTS & SECOND ONE IS SMALL SEGMENTS & BOTH ARE HELD TOGETHER WITH A CLAMP.

3. SUMMATION CT : - THIS TYPES OF CT IN RECTANGULAR OR CIRCULAR IN A SHAPE & USED TO ADD TOGETHER THE OUTPUTS FROM SEVERAL CT's.
4. WOUND –PRIMARY : - IN THIS TYPE THE CONDUCTOR IS WIRED INTO THE CT RATHER THAN PASSING THROUGH IT.

CURRENT TRANSFORMER P1 P2 CONNECTION.

ALWAYS CONNECT P1 OF CT MUST POINT TOWARDS THE SOURCE / SUPPLY & P2 CONNECT TOWRDS THE LOAD.

CT PROTECTION : - ( PS 5P10 OR5P20 ) TYPE IS DESIGNED FOR LOW ACCURACY & HIGH SATURATION BECAUSE DURING FAULT CURRENT IS VERY HIGH,& GIVES INPUT TO RELAY.

5 – ACCURACY CLASS.( ERROR RATIO OR ACCURACY OF THE CT )

P – PROTECTION.

10 – 10 TIMES OF RATED CURRENT.( ACCURACY LIMIT FACTOR )

OR

20 – 20 TIMES OFRATED CURRENT. ( ACCURACU LIMIT FACTOR )

WHICH ONE IS BETTER 5P10 IS OR 5P20 FOR PROTECTION.IT IS NOT RECOMMENDED TO EVALUATE WHICH ONE IS BETTER,AS BOTH ARE GIVING LESS THAN 5% ERROR WHILE MEASUREMENT,5P10 GETS SATURATED OVER AND ABOVE 10TIMES OF RATED CURRENT WHERE AS OTHER ONE AT 20 TIMES.

ITS APPLICATION WHICH DIFFERENTIATE THE USE OF 5P10 ND 5P20.

IF THE CIRCUIT BREAKER IS USED FOR BACKUP PROTECTION SAY INCOMMER WE CAN USE 5P20. BUT IF IT IS SAY AN INCOMER ACB,MCCB YOU SHOULD USE 5P10 ONLY.

CT METERING :- ( 0.1 0.5 OR 1 ) TYPE IS DESIGNED FOR HIGH ACCURACY & LOW ER SATURATION,& GIVES INPUT TO AMMETER.

# ENGINEERING DETAILS

PS : - PS STANDS FOR" PROTECTION SPECIAL ". THIS TYPES OF CT's ARE USED FOR SPECIAL PROTECTION SUCH AS DIFFERENTIAL PROECTION & DISTANCE PROTECTION.GENERALLY USED IN S/S.

1. MAAT = MINIMUM ANNUAL AVERAGE TURNOVER.
2. LOI = LETTER OF INTENT.
3. LOA = LETTER OF ACCEPTANCE.
4. JMR = JOINT MEASUREMENT REPORTS.
5. STAGE INSPECTION : -

# ENGINEERING DETAILS

## II SOLAR ENERGY II

ABOUT PHOTOVOLTAICS :- PV IS THE NAME OF A METHOD OF CONVERTING SOLAR ENERGY TO DIRECT CURRENT ELECTRICITY USING SEMICONDUCTING MATERIALS.

SOLAR ENERGY GATHERED BY PHOTOVOLTAIC SOLAR PANELS,INTENDED FOR DELIVERY TO A POWER GRID OR PROCESS TO USE BY A GRID CONNECTED INVERTER. BASICALLY AN INVERTER CHANGES THE DC INPUT VOLTAGE FROM THE PHOTOVOLTAIC TO AC VOLTAGE FOR THE GRID. THIS INVETER SITS BETWEEN THE SOLAR ARRAY & THE GRID, THE INVERTER MUST MONITOR GRID VOLTAGE,WAVEFORM & FREQUENCY & ONE REASON FOR MONITORING IS IF THE GRID IS DEAD THAT TIME INVETER MUST NOT PASS ALONG ANY SOLAR ENERGY TO GRID. ANOTHER REASON FOR THE INVERTER MONITORING,FOR NORMAL OPERATION THE INVERTER MUST SYNCHRONIZE WITH THE GRID WAVEFORM,& PRODUCE A VOLTAGE SLIGHTER HIGHER THAN THE GRID ITSELF,

### II ANTI ISLANDING II

ISLANDING IS THE CONDITION IN WHICH A DISTRIBUTED GENERATOR CONTINUOUS TO POWER A LOCATION EVEN THOUGH POWER FROM THE ELECTRIC UTILITY GRID IS NO LONGER PRESENT. ISLANDING CAN BE DANGEROUS TO UTILITY WORKERS,WHO MAY NOT REALIZE THAT A CIRCUIT IS STILL POWERED,EVEN THOUGH THERE IS NO POWER FROM THE ELECTRICAL GRID.IN OTHER WORD AN ELECTRIC UTILITY BLACKOUT IN A GRID CONNECTED PV SYSTEM ,THAT TIME SOLAR PANELS WILL CONTINUE TO DELIVER POWER AS LONG AS THE SUN IS SHINING. FOR THAT IS THE REASON, DISTRIBUTED GENERATOR MUST DETECT ISLANDING & IMMEDIATELY STOP PRODUCING POWER,THIS IS REFERED AS ANTI-ISLANDINNG & FOR THIS IS REASON SOLAR INVERTERS DESIGNED TO SUPPLY POWER TO GRID ARE GENERALLY REQUIRED TO HAVE AUTOMATIC ANTI-ISLANDING CIRCUITRY IN THEM.

NORMALLY THERE ARE TWO TYPES OF ANTI-ISLANDING METHODS.THESE ARE FOLLOWS.

1. PASSIVE METHOD.
2. ACTIVE METHOD.

# ENGINEERING DETAILS

*THANK YOU*